HEATING VENTILATING

A MONTHLY MAGAZINE FOR ENGINEERS AND CONTRACTORS CONCERNED WITH COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL AIR CONDITIONING, REFRIGERATION, AIR SANITATION, PIPING, HEATING AND VENTILATION

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THIS MONTH'S COVER

Pipelines connect a tanker terminal and a refinery of the Colonial Beacon Oil Co., at Everett, Mass., and carry various petroleum fuels. Hose lines run from the tanker to the fixed pipes. Photo, courtesy of Standard Oil Co. (N. J.)

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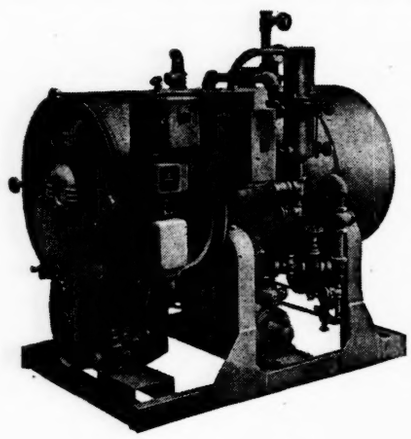

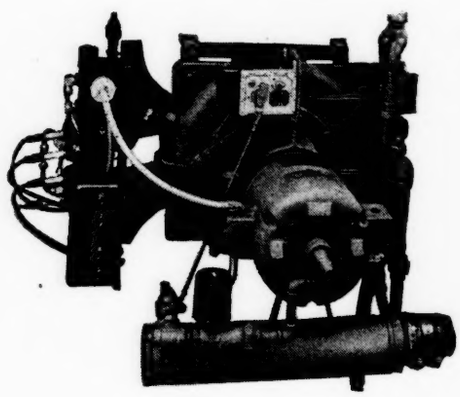

Locating the Panel in Radiant Heating Systems

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Project Engineer,
Chase Brass & Copper Co., Waterbury, Conn.

THE selection of the proper panel location should be considered carefully in all cases. It is not possible to set up "hard and fast" rules covering every structure and in order to derive the most feasible solution, the designer should be acquainted with the major properties of the various panels. This article attempts to name some of the more important advantages and disadvantages of the ceiling, wall and floor system and, by this means, to enable the designing engineer to select the panel for his individual case. The reader will soon discover that for every advantage to each panel, there may be cited a disadvantage. For actual design, it will be necessary to weigh the importance of each panel's qualification with the overall properties of the heating system. However difficult this balance of properties may prove to be, it should be considered that the physiological conditions met in any well-designed radiant heating system are superior to those of the conventional heating system.

General Considerations

One of the questions met most frequently in discussions of radiant heating systems is: "What is the preferred panel location, floor or ceiling?" This question, as most others of such general nature, cannot be answered without giving a thorough study to the conditions of the individual case.

From the historical point of view, it seems that the preference for these various systems changed throughout the ages. The old Romans preferred wall installations—at least for their upper floors—underfloor ducts for the ground floor. Present-day Europeans and the English prefer the ceiling system, while the United States of the 1940's apparently favored the floor system. However, this variance is related rather to the preferred construction methods used in the various countries at the time considered than to the physical properties of each system. The ancient Romans found it less difficult to include large air ducts in the walls than in intermediate floors or ceilings. The present European structure is such that the ceiling plaster may be applied heavy enough to enclose ½ inch and ¾ inch pipe and tubes, and in the United States the floor system gained popularity particularly during the war years when most of the installations provided heat for industrial buildings.

The heating engineer confronted with the design of a radiant heating system will, however, base his decisions not only on structural or historical data, but rather on several or all of the following considerations:

(A) Design for optimum physiological comfort;
(B) Design of the physical properties of the system to fit into the structure specified by the architect;
(C) Provision for highest fuel efficiency combined with reasonable first cost for the system; and
(D) Consideration of local or individual conditions, such as room occupancy, change of occupancy, large glass areas, great height, inertia of panel, climate, exposure, location of furniture, and so on.

In the following, the individual requirements will be discussed. By analysis of examples, it will be seen that, frequently, one certain desired room condition will call for, let us say, a floor system, and another desired condition of the same room for a ceiling panel. It will be the designer's responsibility to decide to which of those two conditions he has to conform more urgently and to select among ceiling, floor or wall panels.

Comfort Conditions

Radiation and Convection. One of the advantages claimed for radiant heating systems is that convective heat loss from the human body is aided and loss by radiation reduced. The heat emission by radiation from the heating panel raises the temperature of the unheated walls, which secondarily lose part of their heat by convection to the room air. The result is a higher mean surface temperature of all room enclosures (MRT) and a lower room air temperature resulting, in turn, for a given moisture content, in a higher relative humidity throughout the building with radiant heating. This is considered to be an advantage of the radiant heating system.

The greater the radiant component of the entire panel output, the more marked become the previously described conditions. See Table 1.

According to Table 1, which compares the radiant components for one "average" room with the entire ceiling, one entire wall, or the entire floor heated, it is obvious that the ceiling system best conforms with one of the main comfort requirements: Maximum radiation output and maximum increase of convective loss of the human body.

Uniformity of Surface Temperatures. Physiological conditions in a heated room may not be considered satisfactory if the MRT (mean radiant temperature) of such room enclosures which are opposed to one-half of the human body (e.g., front) differs extremely from the MRT of the enclosures opposed to the other half (e.g., rear) of the body. For example, little comfort is found in an unheated room with cold walls, ceiling and floor shortly after a fire is started—even though the fireplace is hot. A certain uniformity of all surface temperatures throughout the room is desirable and this uniformity may be achieved equally well by a properly arranged floor or ceiling panel. Wall panels located in all outside walls, and only in or near these walls, compare even more favorably. The requirement of uniformity will be discussed with more accuracy in a later section.

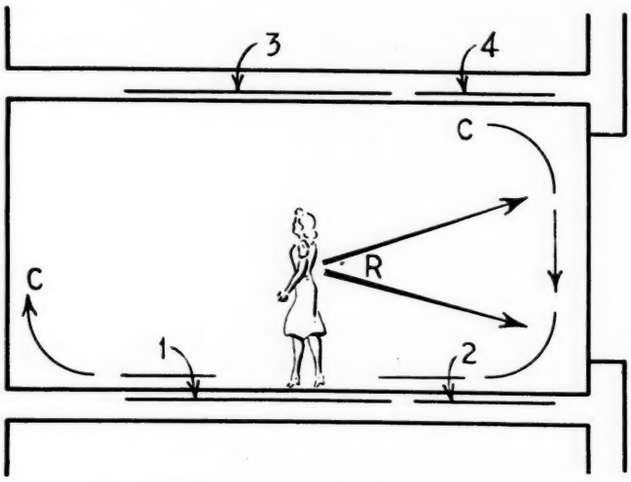


Fig. 1. Example of ceiling and floor panel in intermediate floor.

Suppression of Convection. Excessive convective currents, particularly near the floor surface, whirl up and transport dust particles and are undesirable for this and other reasons. Also, such currents, if caused by the cooling action along the outside wall and the "flue" action of the warmer inside walls (see Fig. 1) are undesirable because of occurrence of stratification and particularly of a cold, low, air layer along the floor. Such currents may be readily avoided by wall panels and also by properly located floor and ceiling panels—that is, by concentrating the major part of the panel output near the outside enclosure as will be described later.

Proper ceiling panelling is particularly favorable in preventing convective currents, a property that in most every case may be considered an advantage, but may turn to a disadvantage in rooms where heavy smoking occurs and windows are well weatherstripped. In such rooms, heavy smoke layers of relatively small height may so distinctly settle at certain elevations that they interfere with vision at this room level. The remedy is either a mechanical ventilating system or an increase in natural ventilation.

Maximum Surface Temperatures. Not only floor temperatures but also those of the ceilings should be restricted to a feasible maximum. In rooms of 7 ft 6 in. ceiling height, it was found that mean ceiling panel surface temperatures of 110F or even 100F resulted in a "feverish" feeling and headaches. In rooms of greater ceiling height, surface temperatures of 120F and higher may be considered as perfectly comfortable. Obviously, high ceiling temperatures are particularly critical in rooms of low ceilings because of the suppression of convective currents inherent in this system. Result is the generation of a hot air layer of relatively small height near the ceiling surface, which is not unfavorable in high rooms, but which extends down to the upper extremities of the human body wherever the ceiling is sufficiently low.

In general, wall, ceiling and floor panels may be designed for surface temperatures well within the comfort limit.

Panel and Building Structure

Application of certain panels is frequently restricted by the structural details of the building. With few exceptions, it is desirable to embed the tubes fully in the concrete or plaster, and for this reason dimensional restrictions of both have to be considered. Reinforcing rods or steel beams may prohibit ceiling or even floor panels. A thin plaster layer may prohibit the use of ceiling pipe coils larger than ⅜ in. or ½ in. nominal diameter. Hardwood flooring may limit the use of floor panels, or at least call for small tube center spacing and relatively low water temperature, so as to avoid large temperature gradients between the sub-floor surface directly above the tube and the parts of the sub-flooring located between the tube centers. An excessive temperature gradient at this surface may cause cracking of the floors.

Consideration should be given to electric conduits and to local building codes calling for certain minimum concrete covers for fireproof structures, a requirement that may again restrict the application of certain panels. Dry construction again may call for special panels operating with higher water temperature as required to compensate for the low heat conductivity of the building materials.

Fuel Consumption and First Cost

Fuel Consumption. Proper location of ceiling and also of floor panels will distinctly improve the fuel consumption. Raber and Hutchinson[1] have pointed out that, to receive uniform distribution—throughout the room—of the panel's heating effect, it may be advisable to heat only parts of the ceiling area. Better room comfort conditions and fuel savings may be expected to result when using such panels. Floor panels are not as well suited to such treatment because, due to their relatively small output, they

[1]Optimum Surface Distribution in Panel Heating and Cooling Systems; Amer. Soc. of Heat. and Vent. Eng., Jour. Section November, 1943.

TABLE 1.—RADIATION IN PER CENT OF TOTAL OUTPUT OF VARIOUS PANELS.

Panel Type and Condition	Radiation, Per Cent of Total Panel Output
Ceiling panel, 115F	64.4
Wall panel, 105F	52.0
Floor panel, 90F	48.2

have to be designed to cover the entire floor area in most every case.

Different conclusions will have to be drawn in the case of a one-story building. Unless well insulated ceilings are provided in such structures, the heat loss through the ceiling will outweigh the savings achieved by Raber and Hutchinson's suggestions and a floor panel will prove to be more economical. In the special case of a one-story building without basement it may be advisable to insulate the ceiling and provide ceiling panels to avoid excessive losses from the floor panel through the ground to the outside atmosphere.

Provision of a small unheated strip of floor or ceiling adjoining the outside wall will not only reduce the heat (flow) conducted from panel to outside wall, but also will reduce the influx of radiation from the panel to the adjoining portions of this wall and therefore the entire heat loss of the building. Unless particularly heavy insulation is provided at the outside wall, wall panels will call for larger fuel consumption than others. Quite generally, the principle of insulating the "opposite" surface of heating panels adjoining unheated spaces is of utmost importance in fuel savings, and application of such insulation will in all cases pay a dividend in the form of fuel savings.

First Cost. Due to restriction of surface temperature, the output per square foot of various panels in the average room compares as shown in Table 2.

Quite obviously, the required size of the ceiling panel, due to its much greater unit output, is in most cases appreciably smaller than that of the floor panel of the same room. This results in important savings in all instances where ceiling heating may be used. This statement holds true also for rooms of low ceilings where ceiling temperatures of 100F or less are used, if we take into consideration that the floor temperature in such rooms is practically restricted to 85F or less.

However, it is again worth while to analyze every individual case. For example, in very high structures (18 feet and over) the installation—and fuel consumption — of a floor system may prove more economical because of a higher "active" MRT near the floor—that is, where the human body is located —which, in this case, coincides with a lower average air temperature and lower average total MRT throughout the entire height of the building.

TABLE 2.—UNIT OUTPUT OF VARIOUS TYPES OF PANELS

Panel Type and Condition	Output, B.T.U. per Hr. per Sq. Ft.
Ceiling panel, 115F	73.5
Wall panel, 105F	68.0
Floor panel, 90F	39.5

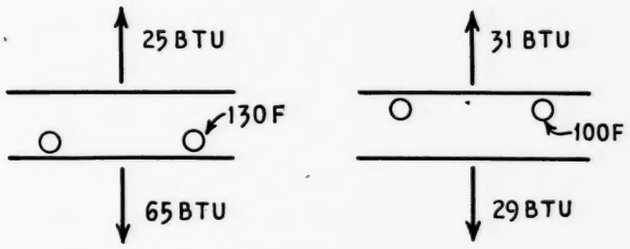


Fig. 2. Compensating for excessive glass areas.

In most cases, the prime investment of wall panels will be found to be lower than the cost of installation of floor panels and higher than the installation of ceiling panels.

First Cost, Panels in Intermediate Floors. Panels located in multi-story buildings and between two heated floors require special discussion.

In Fig. 2, the same coil is located at the left on the bottom, and at the right on top of the intermediate slab. In the first case, to provide for the desired high ceiling panel temperature, the water is heated to 130F. The resulting floor temperature is not much lower than the maximum allowable mean temperature of + 85F and the combined upward and downward heat output of one square foot of panel is 90 Btu per hr. In the second case (floor heating), the water temperature had to be decreased to restrict the heat output of the tubes (and therefore the floor surface temperature), which are in close proximity to the floor. For this second case, the total heat output per square foot of panel is appreciably smaller—only 60 Btu per hour. Obviously, the prime investment may be reduced appreciably when moving the heating coil from the "floor" to the "ceiling" and, generally, the first cost decreases with increasing water temperature.

A similar situation prevails in multi-story frame structures. Wall panels in multi-story buildings will, in almost every layout, prove to be less economical than floor or ceiling panels.

Individual Conditions

Room Occupancy. How the room occupancy may affect the panel selection was shown in the case of the stagnant smoke in a previous section. Another example is a play-room for children. Almost everyone would prefer relatively high floor temperature in such rooms obtained with a floor panel layout. Another example is a gymnasium (or a tuberculosis hospital) where possibly cool air temperature is desired, so that the ceiling panel would be preferred in such cases.

Finally, consider a large, high manufacturing

building, where a future change of machinery and foundations is expected. To avoid later panel changes, the most favorable solution may be the provision of floor panels underneath the aisles. This arrangement will set the machine operators within the sphere of influence of the warm floor and will permit the operation of the building with a slightly lower air temperature. To cover the building's heat loss, installation of supplementary unit heaters may be advisable.

Change of Occupancy. Again, a few typical examples will present the problems encountered. A manufacturing concern has decided, let us say, to move its offices out of the shop building into a new administration building. The original office space is to be used for manufacturing purposes, the linoleum to be removed, and machinery installed. If the previous office space was heated by ceiling panel, few changes will be required. However, if heated by floor panel, removing of the linoleum will throw the building heat supply out of balance; that is, due to the removal of the insulating layer of linoleum, the heat output throughout this altered section will increase appreciably and the mean floor temperature which was less than 85F as long as linoleum covered the floor, will now exceed this maximum allowable temperature. Furthermore, if heavy machinery should be installed, the required new foundations might, at any rate, call for a change of the entire floor panel.

Another example is a nurses' home. Assume that conditions required the removal of a few partitions and by combination of three bedrooms the provision of a new reading room with carpet covered floor. If the bedrooms were heated by ceiling (or outside wall) panels, the system will not be affected by this change. In general, ceiling panels are best adaptable to such changes.

If, for one reason or another (e.g., height of ceiling), it is found that ceiling panels are not desirable, the wall panel remains as the only alternative. This panel will in a few cases only cover the building's heat loss requirements and, to supply the sufficient amount of heat, it will have to be supplemented either by a smaller floor panel or, as previously described, by a combination aisle panel unit heater.

Large Window Area. An excessive glass area will not only induce a great increase of radiation loss in that "half" of the human body that is opposed to this area (*R* in Fig. 1) but also convective currents (*C* in Fig. 1) as previously discussed. To compensate for this glass area either floor or ceiling panels may be arranged according to various schemes as shown in Fig. 1. For instance, by combination of a panel of low surface temperature *1* (or *3*) with a panel of higher temperature *2* (or *4*) we have at hand a method of increasing the mean surface temperature of the room section near the glass area.

This sub-division into low and high temperature surfaces may be achieved by wider and closer tube spacings and without change of the water temperature, particularly with ceiling panels. As previously mentioned, the floor panel in most cases has to be designed for maximum output throughout the room, so as to provide sufficient heat to cover the room heat loss. However, the floor system seems to be more effective in counteracting the convective motion (*C* in Fig. 1). In the case of the large glass area it may seem most advisable to combine the advantages of both systems and provide for either:

(a) Heated panels (*3*) and (*4*) of same surface temperature and heated panel (*2*);
(b) Low temperature panel *3*, high temperature panel *4* and floor panel *2;* or
(c) Floor panels (*1*) and (*2*) of same surface temperature and high temperature panel (*4*).

To compensate for the large glass area, wall heating can be applied according to the same principles as floor and ceiling heating. This is achieved by framing the window area with high temperature wall panels. Again, it may be advisable to combine this panel with either ceiling or floor panel.

Panel Inertia. Inertia is frequently mentioned as an inherent disadvantage of the panel system and this statement deserves some consideration. Systems of little inertia are required only where sudden changes of room temperature conditions occur. Let us next inquire into the possible causes of such conditions.

A sudden change of outside temperature, due to the inertia of outside walls, will certainly be followed by a rather slow change of the room temperature conditions, which will be taken care of by any panel system. One rather unusual case, which, however, is met in practice, is the change of room temperature conditions due to the opening of several windows, causing a rapid drop of the room air temperature. In this case, panel systems will react more slowly than others, especially more slowly than warm air systems.

The sudden changes of the room temperature most frequently occurring and caused by the incidence of sunlight will be compensated for by the radiant heating system better than by any other system. The panel output changes with the fourth power of the difference between panel temperature and temperature of the heat-receiving (unheated) surfaces. Thus, if in a room heated by ceiling panel; sunlight impinges suddenly upon the floor, the panel heat output decreases more rapidly than with any other system. Due to the greater convective component of floor panels (see Table 1) and greater radiation component of the ceiling system, less inertia against sudden change of an air temperature (opening of windows) is inherent to the floor panel and less inertia against sudden influx of sunlight is inherent in the ceiling panel. The wall panel will act much like the floor panel.

Room Exposure. For the previously described reasons and the varying influx of sunlight into rooms of southern exposure, it will be advantageous to use ceiling coils in southern exposed rooms.

Climate. In extremely cold climates and where no auxiliary heating—as by unit heaters—is desired, use of ceiling panels with their higher unit heat output will prove imperative. In very warm climates, and where it is desired to employ panel heat eventually in combination with dehumidifying equipment

for summer cooling, ceiling panels must be provided. Floor panels should not be used for cooling purposes.

Furniture. Arrangement of furniture may appreciably change the radiation properties of panels. The most typical example is the application of heavy carpets on floors. If in a floor-heated dwelling, all floors were computed with (or without) floor cover and later on one room is deprived of (or receives) this cover, the heating system is thrown off balance. For this reason it will be advisable, if floor panels are desired, to provide for easily-accessible individual regulating valves, or for easily-accessible interchangeable orifices in each panel supply connection. The same consideration holds true for the change in location of heavy furniture, that is, from one room to another, in a wall-panelled dwelling. Generally speaking, the ceiling panel is the most flexible because no changes of its properties are caused by any change of the arrangement of the room.

An attempt has been made to consider most of the factors influencing the choice of panel location.

Based on exhaustive analysis of a large number of actually installed radiant heating systems and laboratory test panels, the author has derived a panel heating theory and developed practical design graphs, which shortly will be published in a radiant heating manual.

Among the conclusions resulting from his study are those appearing in the accompanying article, the first one of a series concerned with various radiant heating problems.

Physiological, structural, and local conditions seem to point to the fact that advantages and disadvantages are fairly evenly distributed between floor, wall and ceiling panel, and that for this reason careful consideration should be given to each individual case. The prime investment in almost every instance will be smaller with ceiling systems, and this fact will favor the ceiling system in all cases where the physiological and local advantages of all three systems otherwise balance.

In conclusion the reader should be cautioned on one point: However important it seems to select the proper kind of panel, it is even more important properly to design the system selected. If it is found, for one reason or another, that one of the three systems—say the wall panel—seems preferable, a well-designed ceiling or floor panel will give greater satisfaction to the user than a poorly designed wall system.

(*In the subsequent installment of this series, Mr. Vanderweil will discuss panel expansion, temperature gradients, and some construction details.*)

Copper Man Duplicates Human Temperature System

Out of the General Electric Laboratories comes a copper man. When he has completed his public engagements as an exhibit he will spend most of his time in a cold room in sub-zero temperatures wearing electrically heated clothes.

In the development of electrically warmed clothing for fliers and their implements, cold chamber testing is so vital that Dr. Victor Guillemin of the Wright Field Aero-Medical Laboratory and others thought it desirable to devise a robot. He asked G.E. engineers to make a full-size "copper man." Their substitute duplicates almost exactly the human temperature system and solves the problem of testing electrically warmed flying suits, gloves, shoes and blankets at low temperatures without inflicting suffering and danger on human beings.

The copper man is 5 feet 10½ inches tall. He has a copper "skin" 1-16 inch thick. When he is in operation he loses his copper sheen. To increase his radiation he has a finish black as ebony.

The temperature of different parts of the human body varies considerably. Thus the face and hands, which are normally more exposed may vary widely in temperature without harm or discomfort, but the trunk must maintain a more uniform temperature. Hence the copper man is so wired that different parts and members of his body radiate different degrees of heat. He is divided into fifteen areas. The amount of energy delivered to each can be individually controlled.

When human volunteers were tested in low-temperature chambers the observers had to face the problem presented by different reactions. If a man had just eaten a big meal or he had been out late the night before, his body temperature would be too high or too low, depending on his constitution. It was impossible to maintain standards.

The copper man displays no such idiosyncrasies. His body temperature can be standardized so that he is more suitable for testing than if he were alive and given to having a good time. If his feet are to be chilled—well, the experimenter simply gives him cold feet, and there is no danger of frost bite. The outside observers are just as comfortable as he is. The wiring comes out to a control panel in another room, with the testers sitting in comfort and taking readings from their instruments, as they regulate the copper man and the conditions in the cold chamber at will.

Recognizing the importance of developing better hand and foot protection the Aero-Medical Laboratory ordered for the copper man four separate hands and four separate feet and remote control equipment for these. These hands and feet are important in determining the proper design of electrically warmed clothing.

No. 1 Power Plant, in Virginia City, Minn., which generates steam for light and power. This plant also generates steam for the city's central heating system which serves most of the developed area.

District Heating Serves Small Houses

VIRGINIA CITY, Minn., a city of 13,000 persons located in the iron mining district of Northern Minnesota, is fast becoming a city without chimneys due to its central heating system. New buildings do not have chimneys; old buildings have them as a leftover from earlier architectural designs.

The municipally owned heating system is a non-profit utility, burning annually 43,000 tons of bituminous coal at $7 a ton. The average householder with a five-room house pays $70 a year for heating and hot water service, or about one-half of what he would pay if he had his own heating system. Winters are long with temperatures of —30 to —50F quite common.

City Virtually Smokeless

Steam generated is also used for producing electric power; some directly enters the transmission main. Before relating how all this developed, it is well to point out some of the outstanding benefits of this system. As the homes do not have individual heating plants, the city does not have to worry about ash removals. Fires, due to home heating systems, were reduced about 40% which gives the city a better fire insurance rate. Virginia City is virtually smokeless, and that means less cleaning and reduced laundry for the housewife.

In 1913 the city acquired a small plant for generating power and for pumping water. It supplied steam heat for about two city blocks. Most of the steam was obtained from a nearby saw mill which had large amounts of waste fuel and steam available. In 1929 the saw mill was abandoned and the city expanded its previously developed facilities. At present there are 2,541 customers for the central heating service.

The total investment in outside distribution mains is about $810,000. The investment in boiler plant and steam generating equipment chargeable to the Steam Heat Department is $400,000. Because extensions are financed by assessments to the houses benefited, the city has no direct financial interest in the outside mains. The system covers practically the entire city with the exception of some outlying section where, at present, it is not practical to extend the lines because of transmission losses.

Main extension cost is assessed against benefited property on the basis of a 10-year special assessment, payable to the city to be credited to the sinking fund for bond retirement.

Steam is supplied to several large office buildings, public buildings and schools, the city hospital, and residences.

Rates are Kept Low

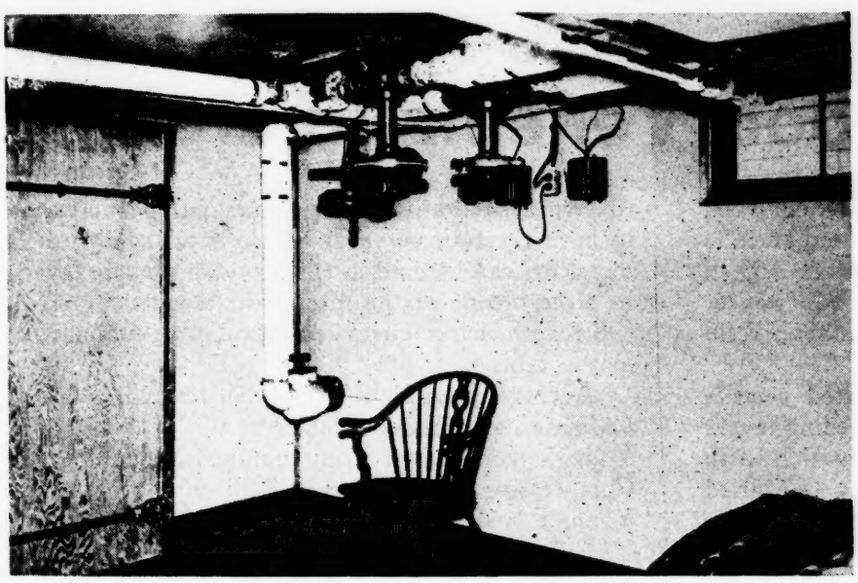
The Commission charges rates to defray the cost of operating and maintaining the plants, plus a reasonable amount for depreciation. From time to time, it has been necessary to make slight additions to the published rate schedule to take care of increased costs of coal, labor and operating supplies. It is not the desire of the officials to build up a large reserve from the profits.

The success of this system can be attributed to the fact that in the early days, low cost steam was obtained from the saw mill, and that the city is so developed that for the most part it is possible to distribute the steam in a more or less densely built up area with the generating plant centrally located.

Homes built before the steam lines were extended, have chimneys.

Newer homes are minus chimneys, coal bins, and furnaces.

The main business street. Note the absence of smokey chimneys. Store fronts do not have to be repainted as often as they are in other cities.



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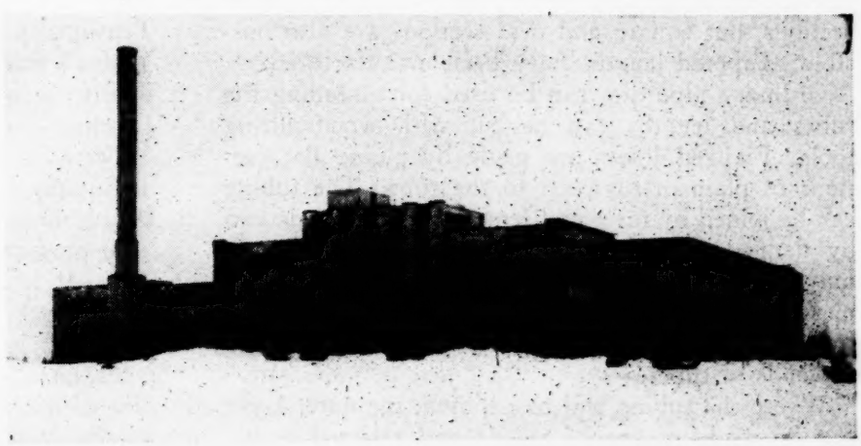
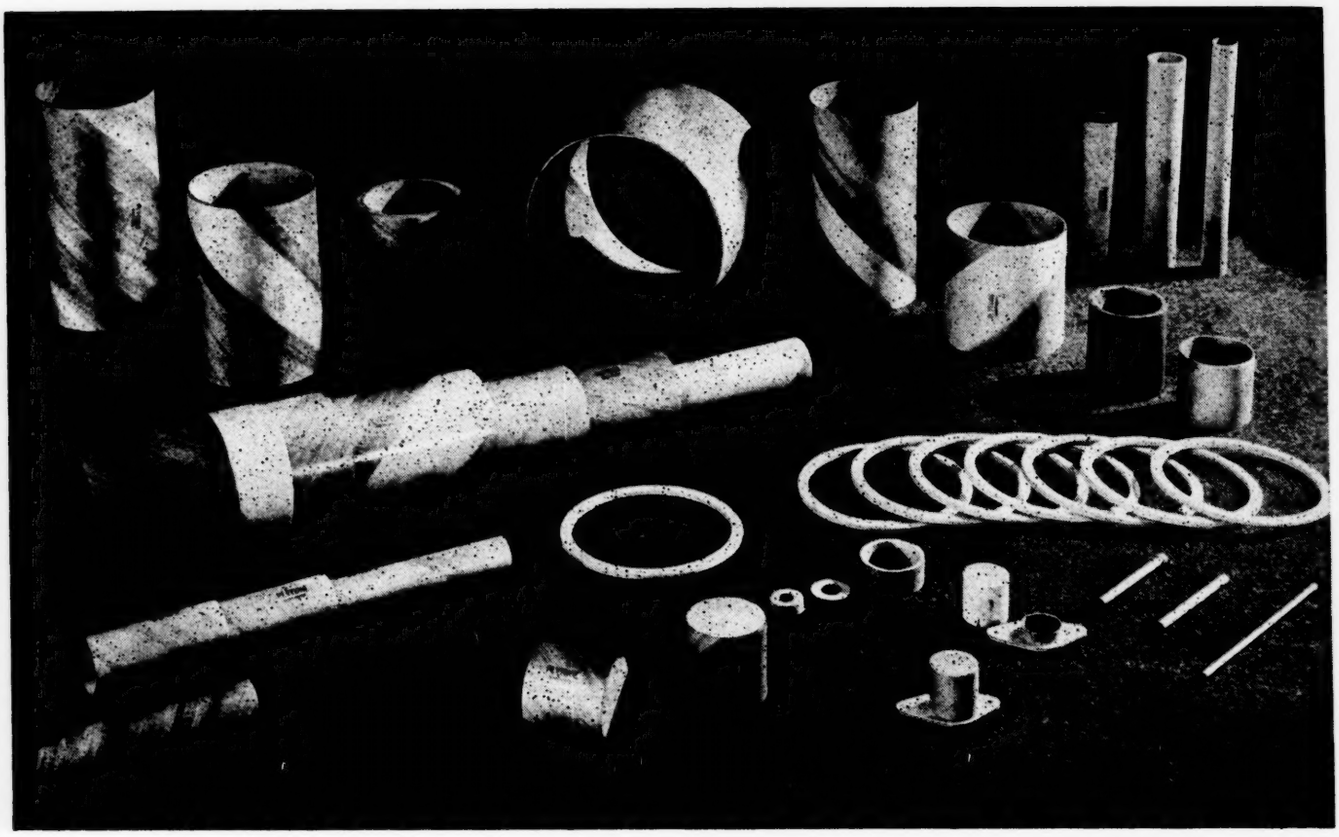
The heating pipe enters the basement and the controls are placed near the ceiling. The entire basement area is easy to keep clean and becomes available for recreation space.

The Virginia High School was erected at a time when a chimney was an essential part of the building design.





Some of the Plytube products made from bonded laminated wood veneers. Various decorative effects are possible.

Laminated Wood Veneers for Tubing

WOODEN tubing made from laminated wood veneers is now available with inside diameters from ¼ to 36 in. and wall thicknesses from 0.03 to 1 in. Close tolerances are possible. The veneer laminates run from 2 to 35 plies. Synthetic resin glues have given best results.

The tubing is made from plastic treated veneers wound spirally on a mandrel, with succeeding layers wound in opposite direction in combination with longitudinal plies. Its construction may be varied to meet particular demands of stress and strain for each application. It is treated to resist rot, corrosion, fungi, termites and splintering.

Not only is the plywood tubing available in round sections, but square and oval sections are also possible. Tapered lengths have been manufactured.

Ordinary pipe dies can be used for threading the tubes and lengths can be cut with wood-cutting tools. Flanged joints are made by gluing flat sections of plain or plywood to the tube. The tubing can be joined by male and female threaded ends and by flanged couplings. While standard wood glues may be used on the threaded fittings, thermosetting plastic resins are recommended for a waterproof joint. Disks and dowels can be used for plugging the ends of tubes.

Where the tubing will be exposed, the outer layer can be made of special woods and selected grains to give a decorative effect. Should it be necessary to have the tube serve as an electrical conductor, a metal foil can be used as the inside or outside layers, in place of one of the intermediate layers.

Strength characteristics of Plytube are summarized in the table.

Average Strength of Plytube in Lb per Sq In.

Ultimate compressive strength	11,500
Young's modulus for axial compression	1,400,000
Compressive proportionality limit	6,000
Young's modulus from buckling failure (Euler's formula)	1,400,000
Ultimate tensile strength	11,000
Young's modulus for axial expansion	1,700,000
Tensional proportionality limit	6,000
Young's modulus for deflection	1,500,000
Specific weight, depending upon specie of veneer and method of construction	.75

Tests conducted at the Harvard Graduate School of Engineering indicate that the tubing approximates the ultimate strength of wood.

At present most of the product is directed for war uses. It is being used in sub-zero climates where metal would be injurious to the touch. Outside of this field, it serves as telescoping radio masts, ski poles, oars, and cases. Present manufacturing facilities of the Plymold Corp., Lawrence, Mass., make it possible to make the tubing in any length.

The Welding of Process Piping

ARTHUR N. KUGLER
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Part 3

THE third major grouping in this classification of families of metals for welding is stainless steel and is covered by box 3-3. It will be appreciated that this also is a vast subject and can be treated here but briefly. It is nevertheless vitally important to the designer of process piping since in this group are included many of the metals necessary to combat some of the more active chemicals. In addition, this group contains those metal alloys best able to stand up under prolonged exposure to high temperatures. Actually as this group is listed in Fig. 1 it covers two major groups of alloys—the straight chrome irons and steels[9] and the austenitic chromium nickel steels.[10]

The metal arc welding process is the method preferred for welding this group of steels for the reason that there are available shielded arc electrodes for use with virtually every analysis of base metal. Oxyacetylene welding, while possible on practically all analyses, is limited by the fact that relatively few filler rods are commercially obtainable—rods of the 18-8 and 18-8 Cb analyses are about all that may be found. Brazing with the silver-cadmium-copper-zinc alloy offers possibilities where the heat of welding might cause difficulties with these critical alloys. Application of the gas shielded arc welding process to this group of metals is so new that complete data are not available.

It is known that excellent weld quality and welding speeds have been secured in the welding of stainless steel tanks. It is also known that with magnesium, one of the first metals to which this process was applied, it is possible to weld vertically, up or down, and overhead. If these same results can be obtained on the stainless metals then perhaps another method of welding this class of process piping will be made available. Braze welding is here included as a possible process but its use should be restricted to emergency repairs or those situations where the copper base alloy filler metal will not cause trouble.

Low Chromium Content Steel

In order to provide maximum information in the space available it will be necessary to treat these alloys in groups. The first is the straight chromium steels containing 3-10% chromium. Included in this are the 4-6% chromium and the 4-6% chromium plus 0.50% molybdenum steels widely used in boilers. Welding of these analyses is best accomplished by the metal arc process using electrodes of the same analyses. Recommended techniques call for preheating to a minimum of 400F or higher if possible. Immediately after welding, without cooling, the welded assembly should be annealed; this will provide satisfactory ductility and impact strength.

In general oxyacetylene welding is not practiced on this steel for suitable welding rods are not available. Low temperature brazing, while a possible operation, would hardly prove satisfactory in the class of service to which 4-6% chrome steel is usually subjected.

Chromium Content of 12-14%

Another group is that covering 12-14% chromium content. This steel is much like those discussed previously, and welding procedures will be substantially the same. Preheating need only be carried to 300F but the importance of annealing before cooling down must be stressed. This analysis is used principally for its resistance to corrosion and oxidation at elevated temperatures, as for example in oil refinery equipment. Again oxyacetylene welding and low temperature brazing can hardly be considered as applicable processes.

The Welding Handbook[9] lists another straight chrome group with a very narrow range—15-16% Cr. This analysis has proven very successful for its resistance to nitric acid. It may be welded with greater ease than any of the lower chrome alloys. Since this alloy is used principally for corrosion resistance it follows that filler metal should be of the same anlysis as the base metal, that is, no lower in chromium content. Arc welding should be employed since shielded arc electrodes of this analysis are available. Preheating to 250F is recommended, while annealing from 1425F yields improvement in properties. Gas welding rods are not commercially obtainable. Silver brazing with the silver-cadium-copper-zinc alloy will not generally prove satisfactory for nitric acid service since nitric acid attacks the silver alloys. Under some conditions, lengthening the depth of lap will retard the corrosive action sufficiently to permit its use.

Chromium Content of 16-18%

The next grouping is that covering 16-18% chromium alloys. An important property of this class is the loss in ductility and impact strength that accompanies the increase in chromium content. This influences the welding of these alloys. Therefore if welds possessing high impact strength are desired, it will be necessary to use austenitic electrodes of the 25-20 or 25-12 types. If, however, it is necessary to weld with electrodes of the same analysis, then preheating at 250F will avoid cracking, which might occur in view of metal brittleness. Annealing may be accomplished in the manner

[9]Welding Handbook—American Welding Society, 1942, pp. 773-800.
[10]Welding Handbook—American Welding Society, 1942, pp. 801-824.

described for the 15-16% chromium steels. Again it must be recorded that oxyacetylene welding and low temperature brazing are not suitable processes for this alloy.

Straight chrome steels containing 20-30% chromium, while admittedly superior for withstanding oxidation at high temperatures, must be classified as exhibiting very poor weldability by any process. This is due to the fact that weld metal in steels containing over 20% chromium is very brittle and is not considered as being of any practical value.

The second group covered under this classification is that of the austenitic stainless steels containing chromium in the range of 16-28% and nickel in the range of 2.5-26%. More than fifteen different analyses are involved, some differing only by small additions of other alloying ingredients. The ability of these alloys to withstand corrosion is closely tied up with the analysis and the metallurgy. Further, the metallurgy is quite involved. Therefore a designer contemplating the use of any of these alloys is urged to study the literature and consult with the manufacturers to obtain the latest data and thus avoid costly errors. Fortunately this discussion may be simplified by the fact that not all of these analyses are available as pipe or tubing.

As an aid to those confronted with problems involving these metals, some of the properties are recorded here; a more detailed exposition may be found in the Welding Handbook[10]. In addition to the outstanding corrosion resistance possessed by these steels the chromium content also increases the

When joining this → to this ↓	STEEL, WROUGHT IRON, AND GALV. IRON	COPPER AND COPPER BASE ALLOYS	STAINLESS STEELS	NICKEL AND NICKEL ALLOYS	ALUMINUM AND ALUMINUM ALLOYS	CAST IRON
STEEL, WROUGHT IRON, AND GALV. IRON	Metal arc welding Oxyacetylene welding Braze welding Brazing **1-1**					
COPPER AND COPPER BASE ALLOYS	Braze welding Brazing Metal arc welding **1-2**	Oxyacetylene welding Braze welding Brazing Carbon arc welding Metal arc welding **2-2**				
STAINLESS STEELS	Metal arc welding Oxyacetylene welding Brazing Braze welding **1-3**	Brazing Braze welding **2-3**	Metal arc welding Oxyacetylene welding Brazing Gas shielded arc welding Braze welding **3-3**			
NICKEL AND NICKEL ALLOYS	Brazing Metal arc welding Oxyacetylene welding Braze welding **1-4**	Brazing Braze welding **2-4**	Metal arc welding Oxyacetylene welding Brazing Braze welding **3-4**	Metal arc welding Oxyacetylene welding Brazing Carbon arc welding Gas shielded arc welding Braze welding **4-4**		
ALUMINUM AND ALUMINUM ALLOYS	Not a practical welding or brazing operation at the present time **1-5**	Not a practical welding or brazing operation at the present time **2-5**	Not a practical welding or brazing operation at the present time **3-5**	Not a practical welding or brazing operation at the present time **4-5**	Oxyacetylene welding Metal arc welding Gas shielded arc welding Brazing Carbon arc welding **5-5**	
CAST IRON	Braze welding Brazing Metal arc welding **1-6**	Braze welding Brazing **2-6**	Brazing Braze welding **3-6**	Brazing Braze welding **4-6**	Not a practical welding or brazing operation at the present time **5-6**	Oxyacetylene welding Metal arc welding Braze welding Brazing **6-6**

Fig. 1. How to join one metal with another. Shaded part indicates the methods discussed in this article.

strength and hardness at elevated temperatures. This is particularly true of the straight chromium alloys discussed previously. Such alloys are magnetic. The addition of nickel renders the alloy non-magnetic and largely austenitic. Such an alloy will exhibit greater ductility than a straight chrome alloy and hence will be more usable. However, some of these analyses are not completely austenitic but display ferritic structures and in consequence are classified as slightly magnetic. The truly austenitic alloys are not susceptible to hardening by heat treatment but may be hardened by cold work.

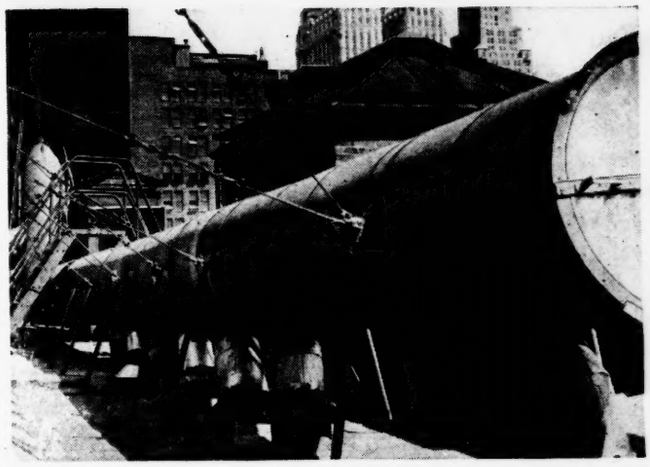
Inhibitor in Metal

Such of these alloys as do not contain inhibiting or stabilizing elements exhibit their greatest corrosion resistance in the annealed state. When heated in the region of 800-1600F, as during welding, some of the elements will precipitate along the grain boundaries and will impair the corrosion resistance. Where feasible this condition may be corrected by heating the entire welded assembly uniformly to a temperature in the range of 1850-2100F, the exact point being dependent upon the specific analysis of the alloy involved. Obviously, such treatment is not always practicable and in such circumstances an alloy containing an inhibitor should be used; the filler metal should also contain the inhibitor. The element titanium when added in amounts four times the carbon content, or columbium at eight times the carbon content, will provide the desired stabilizing action. Titanium treated stainless steels are not considered as desirable for welding as the columbium-inhibited varieties.

Welding with 18-8 Metal

Of the extensive list of alloys covered by this group, the one containing 18% chromium and 8% nickel is probably most frequently encountered. It possesses excellent weldability. For metal arc welding an electrode containing 19% chromium and 9% nickel, minimum, should be used since loss of these elements is inevitable in arc welding and this analysis insures weld metal of 18-8 analysis. For those service conditions where the inhibited alloys are indicated, electrodes containing 19% chromium, 9% nickel and the inhibitor columbium should be used to insure a uniform weldment. Welding with any of these electrodes may be performed in all positions. Further, electrodes of these analyses, but of different types of coating, are available for welding with either d-c reverse polarity or a-c.

These same two alloys (18-8 and 18-8 Cb) may be very successfully welded by the oxyacetylene process using welding rods of analyses the same as the base metal. However in the welding of austenitic chrome-nickel steels by this procedure, it is essential to employ a flux specifically designed to dissolve and to remove the refractory chromium oxide. This flux should be applied to both the base metal and the welding rod. Welding may be accomplished in all positions.



Courtesy, International Nickel Co., Inc.

Fig 2. Monel ventilating duct installed on roof of Eppens Smith coffee roasting plant, New York City. Gas welding and riveted construction used.

Joining of these metals by silver alloy brazing is frequently employed for piping using the silver-cadmium-copper-zinc alloy and an appropriate flux. Obviously since this is true brazing, the lap type joint must be employed. Normally the inhibited 18-8 Cb alloy is not required for silver alloy brazing since carbide precipitation is a function of time as well as temperature, and since brazing takes place so rapidly no ill effects are encountered. The stabilized alloy may, however, be brazed with ease.

While 25-12 stainless steel is normally considered the next logical grouping in any discussion of corrosion resistant steels, it must be remembered that this analysis is not generally furnished in tubular form. In its place the higher nickel content alloy 25-20 is available in seamless tubing. This high chrome-nickel alloy possesses excellent resistance to oxidation at temperatures as high as 2100F in addition to withstanding many corrosive media.

The classes of service for which this alloy is indicated require the use of weld metal with the same proportions of the alloying ingredients. Such filler metal is available in metal arc electrodes commonly known as 25-20 electrodes. The arc welding technique is the preferred method of welding; gas welding rods of this analysis are not commercially available. Post heat-treatment of welds in this alloy is not considered necessary under most circumstances since the as-welded mechanical properties are so high —85,000 to 95,000 lb per sq in. tensile strength and 35-45% elongation in 2 in. However, if this is necessary, it is recommended that annealing be carried on in the temperature range of 1900-2000F, this temperature being maintained in the ratio of one hour per inch of thickness.

In addition to their use for welding alloys of the same analysis, these electrodes (25-12 and 25-20) are used extensively for welding other alloys for which filler metals may not be available or which do not react satisfactorily in the welding operation. In addition, they may be used for overlaying points of severe local corrosion on mild steel parts. Under these conditions the high alloy content offsets the

dilution with the mild steel. One other application of these electrodes, though not commonly encountered in piping, merits consideration for its possible future use; it is the welding of stainless clad mild steel. Here it is common practice to deposit the first pass on the stainless section with either of these electrodes to compensate for any dilution of the alloy weld metal by the mild steel.

Neither braze welding nor brazing can be considered as suitable joining techniques for these alloys since the normal use of these materials is at such high temperatures or under such severe corrosion as to render these methods unsuited. Brazing with the silver-copper-cadmium-zinc alloy can be performed where service temperatures will permit.

Proceeding now to box 3-4, the joining of stainless steels to nickel and nickel alloys, it will be noted that welding of dissimilar metals is here recommended. With certain exceptions noted, it is possible to accomplish this result because the melting points are reasonably close. The order of preference indicated is based on the use of these techniques in industry.

An excellent discussion of this phase of the problem is given in the Welding Handbook[11] covering not only this grouping but several others. In welding these dissimilar metals it is important to avoid deep penetration; therefore high welding currents and puddling must not be employed. For the joining of 18-8 stainless steel to nickel an inconel electrode is recommended; or the connection may be effected with the stainless steel electrodes. However, for the combination of inconel with stainless steel, only the inconel electrodes are recommended. The welding of monel to stainless steel is not recommended.

Substantially the same recommendations apply to the oxyacetylene welding of these metals. Combinations of stainless steel and nickel or inconel are welded with inconel oxyacetylene welding rods. However, there is one important difference and that is that a flux for welding inconel should be used.

Brazing may also be used for joining these metals, employing the silver-copper-cadmium-zinc alloy in lap type joints. Braze welding with rods of Analyses I, III or IV, while a possible application, would hardly be suitable for the reason that these copper base filler rods cannot withstand the type of corrosion to which either the nickel base alloys or the stainless steels are subjected.

Since the next bracket in Fig 1, box 3-5, again involves connections to aluminum, it must be considered, for the present, an impractical operation; the reasons previously given apply in this instance.

The joining of cast iron to stainless steel—box 3-6—is best accomplished by the brazing process with the silver-copper-cadmium-zinc alloy in the lap or shear type joint. Braze welding with the copper base filler metals could be used if service conditions permitted of such dissimilar metals. Arc welding with one of the higher alloy electrodes might appear to offer possibilities but had best be avoided since the analysis of the resultant weld would be of unknown composition, possibly of an air hardening nature susceptible to cracking.

[11]Welding Handbook—American Welding Society, 1942, pp. 932-933.

Welding Increases Service of Cracked Boilers

Application of the shielded arc process of electric welding for restoring old, worn and broken items of all kinds is becoming more and more prevalent in these days of acute shortages of material for domestic use. One of the most prominent applications of this kind has been the repair of cast iron boilers according to reports received by the The Lincoln Electric Company, Cleveland, Ohio.

For example, the Atlas Welding and Boiler Works, New York City, repaired about 200 apartment house boilers by welding during the past 18 months. Although other repair methods were tried, such as tapping and adding plates, they proved to be considerably inferior to the following welding procedure used by the company.

The crack in the boiler is first beveled with a hand chisel to about one-half the thickness of the cast iron plate which ranges from ½ in. to 1 in. in thickness.

A bonding layer of mild steel electrode, especially recommended for welding cast iron, is first applied, then successive layers of weld metal are applied using a ⅛ in. rod of American Welding Society specifications E-6012 in two, three or four passes, depending upon the plate thickness.

A weld penetration of about 50% is usually made with the welder set at 100 amperes as the boilers are generally of the low pressure type and do not require a deeper penetration.

Boilers, which range in weight from 1 to 5 tons, are skip welded to prevent distortion or cumulative strains in the cast metal, then finish welded as illustrated to effect a tight water-proof seam.

Finish Welding a cracked apartment house boiler by the electric arc method.

Fundamentals of Fluid Flow

J. M. Dalla Valle

HEATING AND VENTILATING REFERENCE SECTION

Fundamentals of Fluid Flow

J. M. DALLA VALLE

This is the first of a series of sections presenting the laws governing the flow of fluids in pipes as simply and concisely as possible, and covering not only the theoretical aspects, but practical data of general use to engineers as well.

Information on the flow of fluids in pipes has been published in various forms, perhaps to a greater extent than any other subject of engineering importance, and it might seem superfluous to develop still another treatment. However, the subject is of perennial interest, and although from a theoretical standpoint it is almost as perfectly adaptable to mathematical treatment as mechanics itself, some of its simplest phases are unpredictable. Were we concerned only with pipes or ducts, elbows or orifices, there would be little need for repetitious publications. But from a practical point of view we must consider pipes which are not perfect but possess internal roughness, and are equipped with valves and connections of all kinds and shapes. Losses in such instances are determinable only by experiment, and since no complete system is like any other, basic practical data as comprehensive or specific as possible are always welcome. Each year our knowledge of fluid flow in pipes is augmented by researches on new types of pipe fittings and their performance. This makes the subject one of active interest.

In considering fundamentals in this series, the only desire is to stress the basic background of the general problem itself. Portions of the theoretical treatment are new. For the sake of simplicity the mathematical portions are restricted as much as practicable. This somewhat limits the comprehensiveness, but only insofar as the more advanced phases of the subject are concerned. All items of practical importance will be covered and explained as fully as possible.

FLUID PROPERTIES AND FLOW

FLOW is affected by both the density and viscosity of the fluid in question. Consider the tank in Fig. 1. containing a fluid of density p'. At a point h above the orifice O visualize a small cube of each liquid, say 1 cu cm. Then the potential energy of the cube is $p'h$. An opening at the bottom of the tank will have a flow with a velocity directly determinable from the equation of energy. Assuming no loss of energy through the opening, potential energy at point h above opening = kinetic energy at opening.

This fact may be stated algebraically as:

$$p'h = \frac{p'v^2}{2g}$$

where v is the velocity at point of issue, g the gravitational acceleration, and p' the density. Thus

$$v = \sqrt{2gh} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

which is an equation of universal importance in the flow of fluids. The velocity is independent of the area of the orifice O, and v will be in feet per second if g is in feet per second per second. This equation is perfectly general and states simply the well known law that under gravity all objects dropped from a given height possess the same velocity at any point of their downward motion. Thus, density in no way alters the motion of the fluid, affecting only its energy, the heavier liquid having a greater potential and kinetic energy under identical conditions than the lighter, always provided they are equally viscous.

If the area of the opening in the tank is a, the volume of flow Q is given by the relation

$$Q = av = a\sqrt{2gh} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This equation holds at all times, as long as h does not change. Naturally, as the height of the fluid decreases from its initial position, and hence from moment to moment, Q will change with h. If we know h at every instant, Q (and hence v) will be completely determined at that instant by equations (2) and (1).

Fluids are affected by temperature and pressure, and corrections are often necessary. In the case of liquids, which are regarded as incompressible, we must know their expansion coefficients. At ordinary temperatures these are small and may usually be neglected. On the other hand, gases are markedly affected by both temperature and pressure. Gases obey fixed laws of behavior which permit us to convert from one set of conditions to any other without loss of accuracy.

The density of a gas varies inversely as the absolute temperature T, which is $459.6 + t$, where t is the observed temperature in F. Hence, if P'_1 is the density at temperature t_1, and p'_2, the density at temperature t_2

$$\frac{P'_1}{P'_2} = \frac{459.6 + t_2}{459.6 + t_1} = \frac{T_2}{T_1}$$

Also, the volume of the gas V, and hence h, is

$$\frac{V_1}{V_2} = \frac{h_1}{h_2} = \frac{p'_1}{p'_2} = \frac{459.6 + t_1}{459.6 + t_2} \quad \ldots\ldots\ldots\ldots (3)$$

From this equation we may convert a given height of a *gaseous* fluid at one temperature to its height at any other temperature.

Again, with increased pressure we know that gas volumes are reduced in accordance with the equation V varies as 1/p, where p = pressure. For a column of unit area and height h we have h varies as 1/p. Thus, for converting height from one pressure to another

$$\frac{V_1}{V_2} = \frac{h_1}{h_2} = \frac{p_2}{p_1} \quad \text{.....(4)}$$

Equations (3) and (4) serve to convert volume, height, or density of a gas from one temperature and pressure to any other temperature or pressure.

Example. Air from a drying kiln at 576F flows into a stack at the rate of 7.1 lb per min. What will be the volume when it is cooled to 70F? Take the density of air as 0.0749 lb per cu ft.

(1) The density of air at 576F is, from Equation (3)

$$\frac{p'}{0.0749} = \frac{459.6 + 70}{459.6 + 576}$$

$$p' = 0.0383 \text{ lb per cu ft}$$

Hence, 7.1/0.0383 = 185 cu ft.

(2) From Equation (3), the volume at 70F will be

$$\frac{V}{185} = \frac{459.6 + 70}{459.6 + 576}$$

$$V = 94.6 \text{ cu ft}$$

Example. Given a U-gauge connected to a duct in which air is flowing at room temperature, 70F. If the water in the gauge indicates a deflection of 3 in., what is the equivalent height of air column indicated? Take the density of water as 62.31 lb per cu ft and that of air 0.0749 lb per cu ft. Three inches = 0.25 ft. Hence, since the height will vary inversely as the density,

$$\frac{\text{(ft of air)}}{\text{0.25 (ft of water)}} = \frac{62.31}{0.0749}$$

$$\text{(ft of air)} = 204 \text{ ft}$$

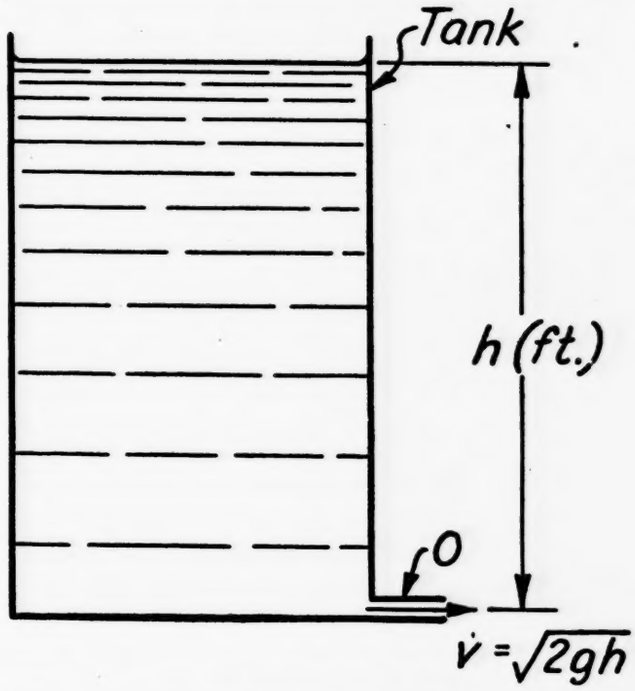


Fig. 1. Velocity of fluid flowing from tank is independent of the density of the fluid.

In general, the relationship between pressure, volume and temperature of gases and vapors is expressed by the equation

$$pV = BT$$

where B is called the gas constant.

If we are concerned with two fluids having the same density, but different degrees of viscosity, there is a marked effect on the rate at which the fluids will issue from a tank as shown in Fig. 1. This is due to the difference in the "internal" friction of the fluids. Equation (1) is still of value, but only if the walls of the tank are very thin. If the thickness of the walls is appreciable, or connected to a short length of pipe as in Fig. 1, the resistance of the fluid to its own motion may be quite high.

Actually the motion of a viscous fluid is nothing more than the application of a shearing force between successive layers of the fluid which are at an infinitesimal distance apart. If the rate of shear is constant throughout the fluid, which it would be if it were homogeneous and the temperature the same throughout, the coefficient of viscosity n is defined as

$$n = \frac{\text{force}}{\text{rate of shear}} \quad \text{.....(5)}$$

Now if F is written for the force required to keep a plane in a state of uniform velocity v, and 1 is the distance between the layers of fluid and then if the layers are infinitesimal, so that the relative velocities between the layers are infinitely small,

$$n = \frac{F}{\Delta v/\Delta l} = \frac{F}{dv/dl}$$

TABLE 1.—VISCOSITIES OF VARIOUS LIQUIDS AND GASES.

Substance	Temperature		Viscosity	
	C	F	CGS Units	FPS Units
Water	0	32	0.01793	0.00120
	10	50	0.01311	0.00088
	20	68	0.01101	0.00060
	40	104	0.00657	0.00044
	60	140	0.00469	0.000315
Ethyl alcohol	0	32	0.0177	0.00119
	20	68	0.0119	0.00080
	40	104	0.00827	0.000556
	60	140	0.00591	0.000397
Acetic acid (99.6%)	20	68	0.0122	0.00082
	40	104	0.0090	0.00061
	60	140	0.0070	0.00047
Aniline	20	68	0.0440	0.00296
	40	104	0.0241	0.00162
	60	140	0.0156	0.00105
Air	0	32	171	11.49
	10	50	177	11.89
	20	68	192 × 10^{-6}	12.90 × 10^{-6}
	100	212	224	15.05
	302	576	299	20.09
Carbon dioxide	—78	—108.4	103	6.921
	—21	—5.8	129 × 10^{-6}	8.670 × 10^{-6}
	0	32	139	9.341
	20	68	160	10.75
Steam (saturated)	100	212	132	8.9
	148	298.4	152 × 10^{-6}	10.2 × 10^{-6}
	162	333.6	158	10.6
	198	388.4	173	11.6

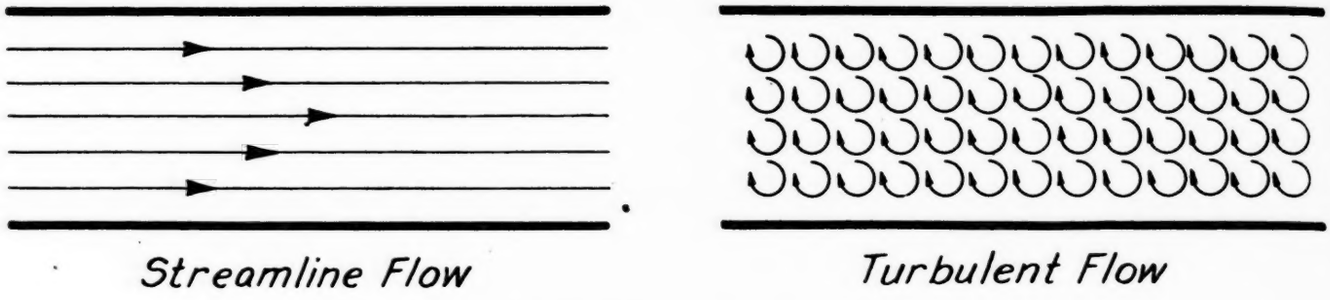


Fig. 2. Streamline (left) as compared with turbulent (right) flow.

and

$$F = n\frac{dv}{dl} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The coefficient of viscosity of a fluid is merely the numerical value of the tangential force on the unit area in question. In foot-pound-second units it is the number of poundals (force or weight ÷ 32.2) required to move a layer of a fluid one foot square at a rate of 1 ft per sec relative to the plane of the fluid one foot removed from it. The intermediate areas will of course move at intermediate velocities, which may or may not be linear.

Equation (6) is just the force needed to maintain the motion of the fluid at a uniform velocity against *internal resistance*. Thus, if we know the viscosity of the fluid and the rate of change of speed, we can calculate the force required to maintain motion.

We must soon realize, and it will be stressed again later, that the importance of viscosity in fluid flow disappears if the flow is turbulent. Obviously, if the flow is made up of vortices, the shearing forces are nullified. Also, viscosity will change with temperature. The coefficient of viscosity increases with an increase in temperature. Values for various liquids and gases are shown in Table 1.

Example. Water at 59F is flowing in streamline motion in a pipe 12 inches in diameter. A velocity traverse is made and it is found that at the wall the velocity is zero. At a distance of 4 inches from the wall the velocity is 21 ft per sec. What force must be applied to overcome the internal resistance of the fluid to maintain the velocity found?

Solution. From Equation (5) we have

$$F = n\frac{v}{l}$$

and from Table 1, we see that n = 0.000766 (FPS units); so that

$$F = 0.000766 \times \frac{21}{4} = 0.00377 \text{ poundals per sq ft}$$

$$= 0.121 \text{ lb per sq ft}$$

Before proceeding further some space must be given to a discussion of units. Thus, n from Equation (3) has units determined as follows:

$$n = F \cdot \frac{1}{V} = \left[\frac{ML}{T^2}\right] \cdot \frac{L}{[L/T]} = \left[\frac{M}{LT}\right]$$

where M is mass, L is length, and T is time. Since values of n are usually in CGS units, we give the following rule: *Multiply CGS units of viscosity by 0.0672 to convert to FPS (English) units of viscosity.*

TYPES OF FLOW

When a fluid flows in a pipe or duct, two types of motion are possible. These types of motion are referred to as *streamline* and *turbulent* motion, and their characteristics are shown schematically in Fig. 2. In streamline motion each particle of fluid moves in a straight line. Thus, if in a glass pipe line containing water we introduce a small but constant amount of a dye, the latter will not be dispersed through the fluid but will move as a thin pencil-like streak throughout the length of the pipe. When the flow is turbulent, the dye will at once disperse throughout the liquid, thus indicating the existence of small eddies or vortices.

Osborne Reynolds has shown that the type of flow existing in a pipe is dependent upon the properties of

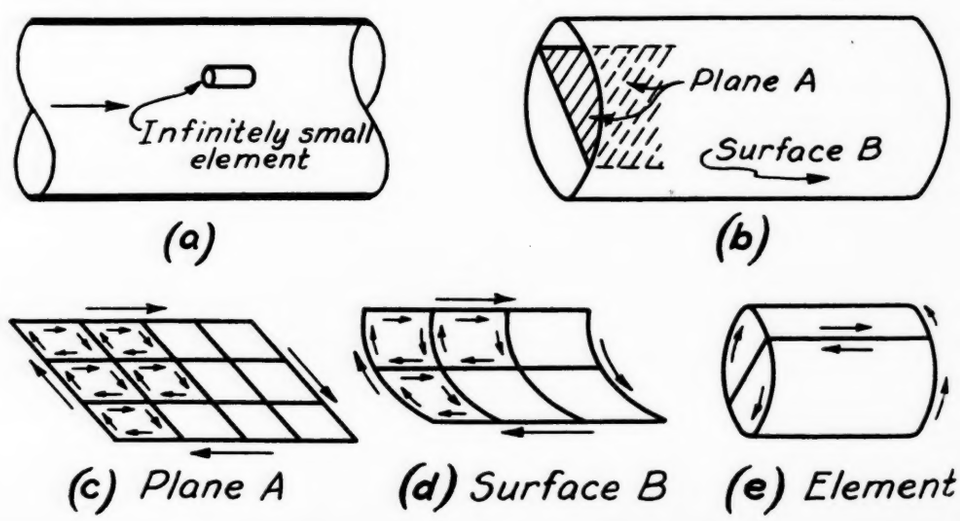


Fig. 3. Diagrammatic proof that viscosity has no effect in a turbulent region.

the fluid (density and viscosity), the speed of flow, and the diameter of the pipe. These variables are connected by the dimensionless ratio called Reynolds' number or Reynolds' modulus, as follows:

$$R_e = \frac{p'vd}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

It is easily shown that this ratio is dimensionless and hence applies to all fluids and pipes. Thus, since $p' = [M/L^3]$, $v = [L/T]$, $d = [L]$, and $n = [M/LT]$, by substitution in Equation (7) we have

$$\frac{p'vd}{n} = \frac{[ML^{-3}] \cdot [LT^{-1}] \cdot [L]}{[ML^{-1}T^{-1}]} = [R_e]$$

which means that if the type of flow is dependent on R_e, a number having no dimensions, then it holds for any fluid in any pipe.

The velocity of a fluid in a given pipe at which the flow becomes turbulent is of great engineering importance, since the resistance or loss of pressure in a pipe is markedly affected by the condition of the flow. Numerous experiments have shown that when $R_e > 2500$ the flow becomes turbulent and remains so; conversely, when $R_e < 2500$ the flow is streamline or "viscous."

Example. Oil having a specific gravity of 0.8420 at 70F is tested in a Saybolt standard viscosimeter at the same temperature. A value of 300 Saybolt seconds is obtained. Assuming that the fluid is to be pumped in a 6 in pipe, what is the limiting velocity that the flow will be streamline?

Solution. (1) In FPS units the time t may be converted into absolute values of n by the formula

$$\frac{n}{p'} = 0.00000237t - \frac{0.00194}{t}$$

$$= 0.00000237 \times 300 - \frac{0.00194}{300}$$

$$= 0.000705$$

(2) Since p' is expressed in pounds per cubic foot, the weight of the oil per cubic foot is

$$62.3 \times 0.8420 = 52.5 \text{ lb per cu ft}$$

$$n = 52.5 \times 0.000705 = 0.037 \text{ FPS-units}$$

(3) For streamline flow

$$\frac{p'v_c d}{n} = 2500$$

where v_c = the critical velocity in feet per second.

$$v_c = \frac{2500 \times 0.037}{52.5 \times 0.5} = 3.50 \text{ ft per sec, the}$$

limiting velocity for streamline flow.

We have shown that a fluid moving in a pipe exhibits internal friction. This is true only when the flow is viscous. In turbulent flow internal friction disappears at all points within the fluid except near the walls. In these regions the velocity approaches streamline flow and the problem becomes complicated. It can be shown diagrammatically that viscosity has no effect in a turbulent region. Consider a pipe as shown in Fig. 3a and let us limit ourselves to a small tube of fluid within it. Further, consider the tube as developed in Fig. 3b and confine the discussion to plane A (Fig. 3c). In this plane we have an infinity of vortices. Divide the region as shown and indicate the direction of flow throughout the matrix as in Fig. 3c. It is evident that within the matrix the flow is completely nullified and we are left with a resultant flow which is the boundary of the plane considered. Now let us develop surface B of Fig. 3b in the same manner (Fig. 3d). Here again the vortices nullify each other and the flow indicated along the boundary is the result. Extend this throughout the region under consideration and we finally obtain the condition shown in Fig. 3e. At the closure the flow is completely nullified, and since no slippage occurs at any point in the element no internal friction exists. Hence viscosity is of no importance in any region of turbulence. The procedure outlined is perfectly general and may be extended throughout all the elements of the fluid.

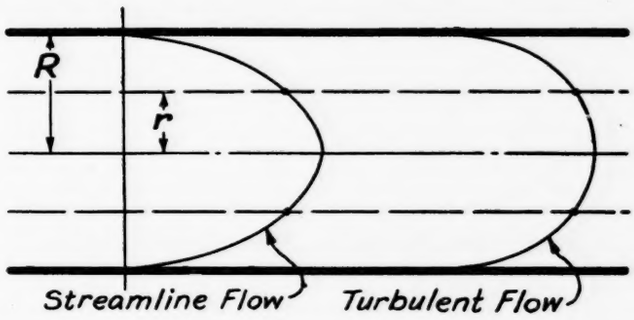


Fig. 4. Difference in velocity distribution between streamline and turbulent flow.

VELOCITY DISTRIBUTION

One of the most remarkable differences between streamline and turbulent flow in a given pipe is to be noted in the cross-sectional velocity distribution. In streamline flow the distribution is always parabolic, whereas in turbulent flow no theoretical formula has so far been deduced for the distribution. Referring to Fig. 4, the velocity v_r at any point r in a round pipe of radius R when the flow is streamline, is given by the equation

$$v_r = \frac{\Delta p}{\Delta n l}(R^2 - r^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where v_r is the velocity at any point at a distance r measured radially from the axis of the pipe, R is the radius of the pipe, n the viscosity of the fluid, and $\Delta p/l$ the pressure drop per unit of length. The average velocity v_{av} is given by the equation

$$v_{av} = \frac{\Delta p}{8w} R^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Hence, if we set $r = 0$ in Equation (8) and so obtain the velocity at the axis (v_a) by dividing Equation (9) by Equation (8) we have

$$v_{av} = 0.5\, v_a \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

That is, the mean velocity v_{av} in streamline flow is one-half the axial velocity.

We frequently desire the average of the square of the velocity distribution, particularly if we are measuring velocity pressures ($h_m = v_m^2/2g$). In this case the average of the squares of the velocities v_m is defined by the equation

$$v_m^2 = \frac{2}{3} v_a^2$$

so that

$$h_m = \frac{2}{3} h_a \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

where h_m is the head corresponding to the velocity v_m and h_a the head corresponding to v_a. That is, the aver-

age velocity head at the center of the pipe is 2/3 the axial velocity head.

In the case of turbulent motion there is no simple formula of general application that measures the velocity distribution. McElroy, on the basis of air tests made within a 16 in. G.I. pipe, obtained the following relation:

$$v_r = v_a \left(\frac{R - r}{R} \right)^{1/7} \quad \ldots\ldots\ldots\ldots (12)$$

Whether this equation is correct for all fluids in any pipe when the motion is turbulent cannot be stated. However, it seems to have given reasonably accurate results in a few cases in which it was tried. In most practical instances the velocity distribution is required to compute the rate of flow, and for this the average velocity must be known. On the basis of many experiments the curve shown in Fig. 5 was found very accurate for all kinds of fluids in smooth round pipes. Thus, for any value of R_e in both the streamline and turbulent ranges we can readily obtain the average velocity in terms of the axial velocity. The curve demonstrates the factors affecting velocity distribution in the turbulent region of flow. Note that for values of R_e ranging from 2100 ($\log R_e = 3.32$) to 2700 ($\log R_e = 3.43$) within the transition zone the ratio of v_{av}/v_{max} is from 0.5 to 0.78. Usual values of v_{av}/v_{max} for most industrial installations where flow is turbulent are from 0.8 to 0.9, a good general average being 8.5.

Example. What is the quantity of water flowing in a smooth pipe 3 inches in diameter at a temperature of 140F if a pitot measurement at the center-line indicates a velocity pressure 3.5 ft of water? Assume density of water to be 61 lb per cu ft.

Solution. (1) $v_{max} = \sqrt{2 \times 32.2 \times 3.5} = 15$ ft per sec, from Equation 1.

(2) $R_e = \dfrac{v_{max} p' d}{n} = \dfrac{15 \times 61 \times 0.25}{0.000315} = 725{,}000$ from Equation 7.

$$\log R_e = 5.86$$

(3) The flow is turbulent and from Fig. 5 we see that

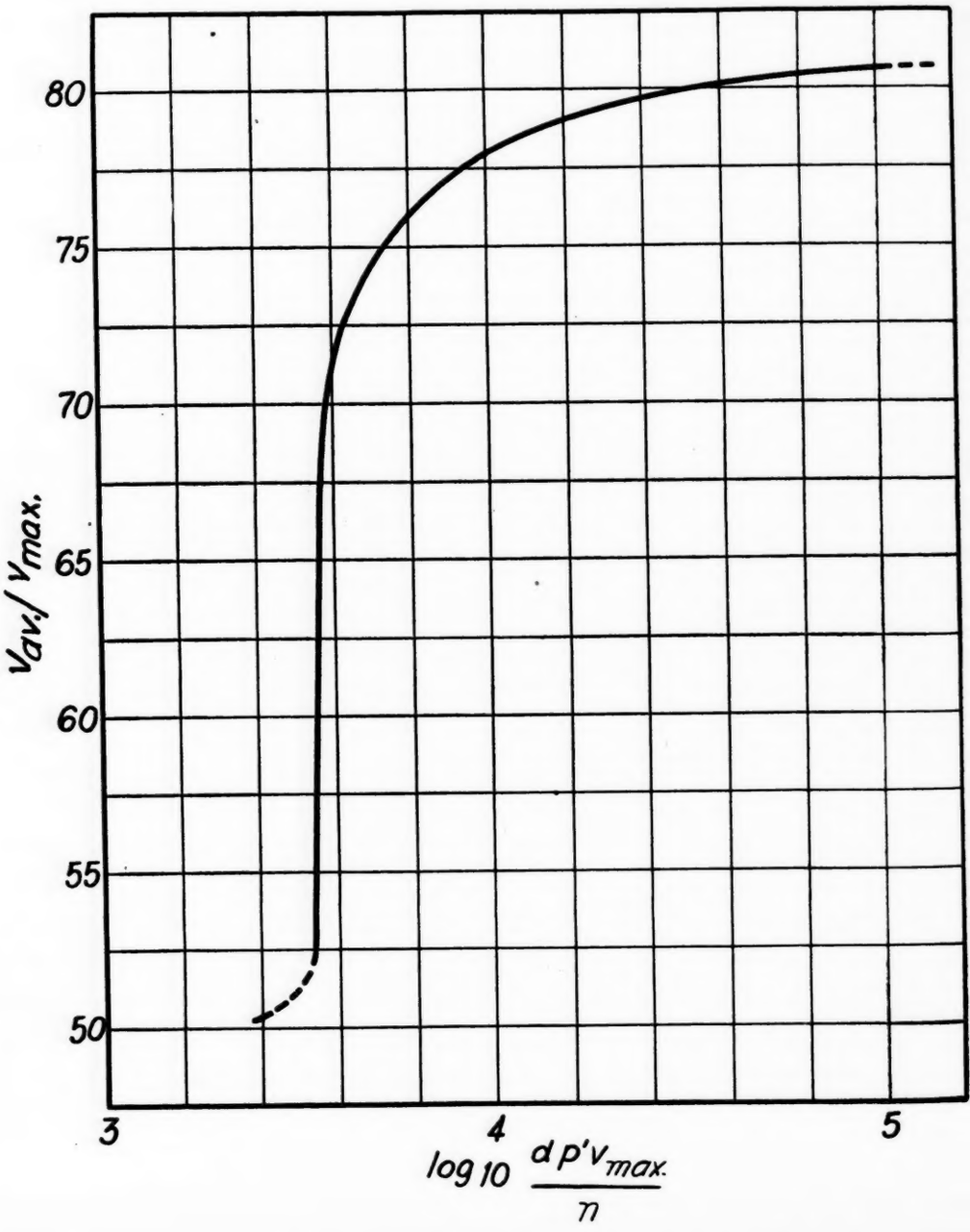


Fig. 5. Ratio of mean velocity (V_{av}) to maximum velocity (V_{max}) in circular pipes, where d is the inside diameter in feet, V_{av} and V_{max} are in feet per second, absolute viscosity n is in pounds per foot-second, and density p' is in pounds per cubic foot.

$$v_{av}/v_{max} = 0.81$$

Hence

$$v_{max} = 0.81 \times 15 = 12.2 \text{ ft per sec}$$

$$Q = 12.8 \times \frac{\pi \times 3 \times 3}{144 \times 4} = 6.0 \text{ cu ft per sec.}$$

DIMENSIONAL ANALYSIS

No review of the theory of fluid flow is complete without some mention of dimensional analysis. One result of this kind of analysis was introduced in Reynolds' number or modulus. Actually this number is nothing more than a ratio of forces or like quantities. If we let L represent any dimensional length, we may write the following forces:

Inertial force $= p'v^2/L$ ..... (a)
Frictional force $= nv/L^2$ ..... (b)
Gravitational force $= p'g$ ..... (c)

where p' is the density of a fluid, n the viscosity, v the velocity, and g the acceleration due to gravity. These are but a few of the forces with which we are concerned in ordinary mechanics. Now, in the flow of fluids we actually have the above three equations to consider. In flow through pipes (a) and (b) are important, while for the flow of fluids in channels (a) and (c) must be considered. If we divide (a) by (b) we obtain

$$\frac{p'v^2}{L} \Big/ \frac{nv}{L^2} = \frac{p'vL}{n} = R_e$$

Since the ratio is of forces having the same dimensions, it is seen that R_e must be dimensionless. If we divide (a) by (c), we obtain

$$\frac{p'v^2}{L} \Big/ p'g = \frac{v^2}{gL} = F_r$$

which is Froude's number. This number is of great importance in channel hydraulics and in ship-model investigations. Like R_e, Froude's number (F_r) is dimensionless. The value of the dimensionless numbers outlined lies in the fact that they incorporate all the forces inherent in all problems involving the *flow* of fluids either in pipes or channels, and hence have a universal application to such problems no matter how the quantities comprising them vary. In the case of (a) above, we may of course substitute pipe diameter d. All the equations, (a), (b) and (c), will apply to any fluid whether liquid or gas, but are not generally applicable in cases where the fluid is plastic since (b) fails to apply in such instances.

We may now proceed to introduce three simple quantities or dimensions. Thus, for mass we write [M], for length [L], and for time [T]. Since velocity is distance divided by time, we have $v = [LT^{-1}]$. Similarly, acceleration is $a = [LT^{-2}]$. The equation for force may be written several ways. For example, $F = M_a$ and $F = Mv^2/_{2g}$. In the first case, $F = [M] \cdot [LT^{-2}] = [MLT^{-2}]$ and in the second $[M] \cdot [LT^{-1}]^2 = [MLT^{-2}]$. Therefore, we see that the dimensions of force are $[MLT^{-2}]$.

Now, in an equation, like quantities must be added, and the dimensions of one side must be the same as those on the other. This being true, we are free to combine dependent variables and discover the relation behind them. This cannot always be done since we may arrive at illogical conclusions. Thus we have Newton's law of gravitation:

$$F = G\frac{m_1 m_2}{R^2}$$

where F is the force of attraction between two masses m_1 and m_2 at a distance R apart, and G is the constant of proportionality or the gravitational constant.

In dimensional form:

$$G = \frac{[MLT^{-2}]\,[L^2]}{[M^2]} = M^{-1}L^3T^{-1}$$

a meaningless quantity because we do not know what variables other than those shown in the equation are related to G. In dimensional analysis one must always proceed with caution in order to avoid such difficulties.

As a comprehensible example let us try to determine resistance E to the fall of a particle in a fluid medium. This will depend upon the following independent variables:

viscosity of the fluid ($n = [ML^{-1}T^{-1}]$)
velocity of the fluid ($v = [LT^{-1}]$)
diameter of the particle ($D = [L]$)

$$E = K\,(n^x v^y D^z)$$

or dimensionally

$$E = [MLT^{-2}] = [ML^{-1}T^{-1}]^x \cdot [LT^{-1}]^y \cdot [L]^z$$

Since both sides of the equation must be the same dimensionally, we must equate the exponents of [M], [L], and [T], thus obtaining three equations

$$\begin{cases} 1 = x \\ 1 = -x + y + z \\ -2 = -x - y \end{cases}$$

whose solution is: $x = 1$; $y = 1$; and $z = 1$. Hence

$$E = KnvD$$

which is Stokes' law for small particles falling in a fluid. For spheres, K, the constant of proportionality, has a value of 3π.

The above is the general procedure used in dimensional analysis. Obviously if more than three variables are involved in any relationship we will have more than three unknowns, but still only three equations. Hence one or more of these unknowns may be indeterminate. Let us determine the resistance of a pipe to the flow of fluid. Assume that the resistance to flow depends upon the following variables: fluid density and viscosity, fluid velocity, and pipe diameter; and pressure drop per unit length. Since the pressure drop p/l is a measure of resistance to flow, select this as the dependent variable

$$p/l = f(p',n,v,d)$$

Also n is not precisely independent, but is proportional to v, p', and d. Implicitly we have that

$$F(p',n,v,d,p/l) = o$$

Let $n = 1 =$ a constant, and assume that the following proportionality exists:

$$K_1 = p'^x, v^y, d^z, p/l$$
$$= [ML^{-3}]^x \cdot [LT^{-1}]^y \cdot [L]^z \cdot [ML^{-2}T^{-2}]$$

$$\begin{array}{l|l} 0 = x + 1 & x = -1 \\ 0 = -3x + y + z - 2 & z = 1 \\ 0 = -y - 2 & y = -2 \end{array}$$

$$K_1 = \frac{d}{p'v^2} \cdot \frac{p}{l}$$

Now take $p/l = k_2 =$ constant while n varies.

$$k_2 = p'^a v^b d^c n$$

and proceeding in the same manner

$$k_2 = \frac{n}{p'vd}$$

Both k_1 and k_2 are dimensionless and whatever the relationship between them, we always have

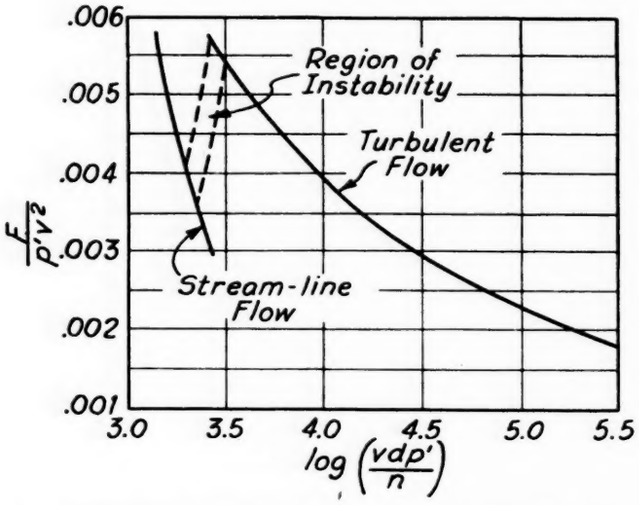


Fig. 6. Resistance of Smooth Pipes vs. Reynolds' Number.

$$f'([k_1], [k_2]) = 1$$

or

$$k_1 = q(k_2)$$

Hence

$$\frac{p}{l} = \frac{p'v^2}{d} \cdot q\left(\frac{n}{p'vd}\right) = \frac{p'v^2}{d} \cdot q(R_e) \quad \ldots(13)$$

Since in streamline motion p/l is proportional to v

$$q\left(\frac{n}{p'vd}\right) = \frac{kn}{p'vd}$$

$$\frac{p}{l} = \frac{knv}{d^2} \quad \ldots(14)$$

We may now digress and put Equation (13) in a slightly different and more general form. Let p denote the pressure difference between two ends of a section of pipe l-units in length and diameter d. Also let R represent the frictional force per unit area opposing the motion. Then, since the frictional force x pipe surface must equal the *net* driving force across the section, we have

$$R \cdot \pi d \cdot l = p \cdot \frac{\pi d^2}{4}$$

$$\frac{p}{l} = \frac{4R}{d} \quad \ldots(15)$$

and substituting this in Equation (13)

$$\frac{R}{p'v^2} \text{ varies as } q(R_e) \quad \ldots(16)$$

Hence, for a given pipe a plot of $R/p'v^2$ vs R_e will result in a fixed curve regardless of the viscosity, density, or velocity of the fluid. The curve will vary *only when the internal condition of the pipe varies.* Such a curve for streamline and turbulent conditions is shown in Fig. 6.

Example. The observed pressure drop in a 6-inch diameter air duct 10 feet in length is 3.2 inches water gauge. Calculate the resistance R opposing the motion of the air. Assume the air temperature to be 70F.

Solution. (1) Since a pressure of 1 inch of water at 70F will support a column of air 68 feet in height, 3.2 inches will support $3.2 \times 68 = 207.6$ ft.

(2) Height of air column times density gives the pressure p in pounds per square foot, or

$$207.6 \times .075 = 20.3 \text{ lb per sq ft}$$

So that for a 6 in. pipe, the total pressure is

$$20.3 \times \frac{\pi \times (6 \times 6)}{4 \times 144} = 4.0 \text{ lb approx.}$$

(3) Since this must be equal to the frictional force $R\pi dl$,

$$R \cdot \pi \cdot \frac{6}{12} \cdot 10 = 4$$

$$R = 0.25 \text{ lb per sq ft}$$

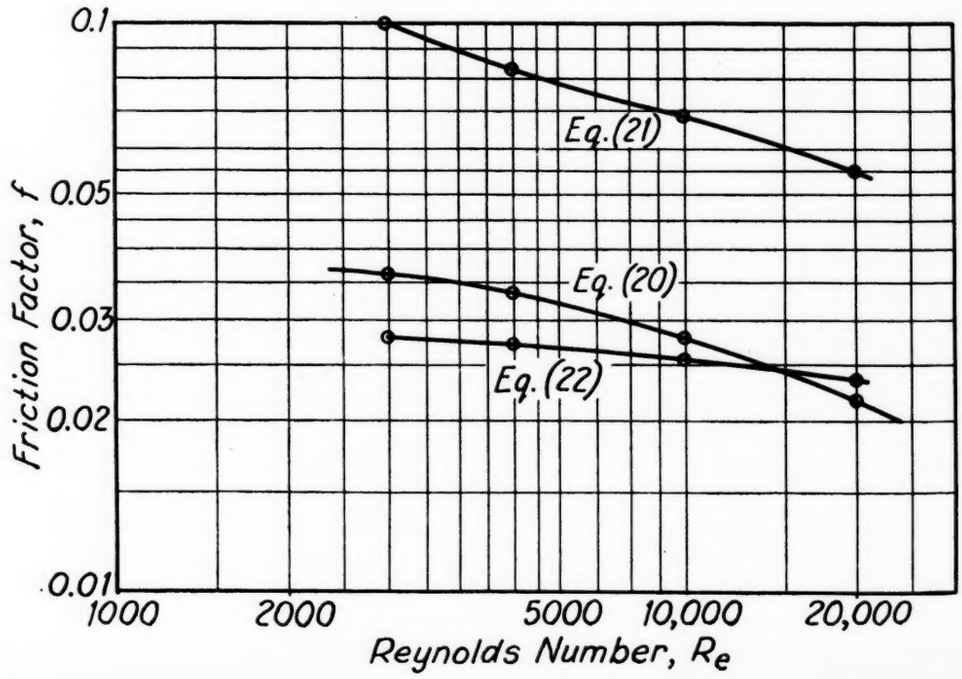


Fig. 7. Comparison of Equations 20, 21 and 22.

WALL EFFECT

When the motion in a pipe is turbulent the distribution of flow in it corresponds simply to that shown in Fig. 4. From this figure we see that near the walls the velocity diminishes and under certain conditions may actually approach streamline flow. Obviously the flow near the wall depends upon the nature of the wall surface. Near the wall a "drag" is induced, which is due in part to the resistance of the wall itself to motion, and in part to the internal resistance of the fluid adjoining. The magnitude of this drag cannot be predetermined and because of this we must rely upon experiment to estimate its extent.

Numerous experiments have shown that the pressure drop per unit length of pipe (p/l) may be expressed in the following manner:

$$\frac{p}{l} = f \cdot \frac{1}{d} \cdot \frac{p'v^2}{2g} \quad \ldots\ldots\ldots\ldots (17)$$

which is a modified form of Equation (13), where f is a "wall" or "roughness" factor which accounts for the effect of the pipe surface on the flow. The value of f, however, is not constant, but is in itself a function of Reynolds' number and an indeterminate wall characteristic. Using Prandl's equation for determining the roughness coefficient, Galavics (1939) found that

$$\frac{1}{\sqrt{f}} = 2 \log (R_e \sqrt{f}) - 0.8 \quad \ldots\ldots\ldots\ldots (18)$$

represents the roughness coefficient for smooth metal pipes. Galavics applied Equation (17) to both streamline and turbulent flow and gave the following values for f.

For streamline flow

$$f = 64/R_e \quad \ldots\ldots\ldots\ldots\ldots\ldots (19)$$

And for turbulent flow

$$f = 0.0032 + \frac{0.221}{R_e^{0.237}} \text{ (approx.)} \quad \ldots\ldots\ldots (20)$$

Equation (18) and its homologue Equation (20) are of great importance since they apply to all fluids. We shall have occasion to refer to them in later sections.

Equations similar to (20) have been obtained by other investigators. Thus, in using the data of Stanton and Powell, Lees derived the expression

$$f = 0.0072 + \frac{0.5341}{R_e^{0.35}} \quad \ldots\ldots\ldots\ldots (21)$$

For saturated steam and other vapors flowing in a smooth pipe, Lander found that

$$f = 0.016 + \frac{1.128}{R_e^{0.44}} \quad \ldots\ldots\ldots\ldots (22)$$

Equations (20), (21) and (22) are shown plotted in Fig. 7. It is clear that for smooth metal pipes the differences are appreciable. This difference may be attributed either to the character of the internal pipe surfaces used by the various investigators, or to wall films. However, it is clear that over the usual range of Reynolds' numbers the change in f is very small for any given pipe. For commercial pipes we may use the modified equation due to Wilson, McAdams and Seltzer

$$f = 0.01/R_e^{0.2} \quad \ldots\ldots\ldots\ldots\ldots (22a)$$

This equation gives values which are much lower than those generally accepted. Fig. 8 illustrates *average* values of f for various pipe sizes and condition of inner surface.

FRICTION IN PIPES

Chezy Formula. Equation (17) may be altered into a form dependent only upon the physical characteristics of the pipe system. The form is usually convenient for hydraulic computations. If h denotes a difference in elevation between the two ends of a pipe of length l in which a fluid flows, $h/l = S$ is the sine of the slope of the hydraulic grade line. Also if $\overline{R}$ is used to define the mean hydraulic radius (cross-sectional area ÷ by wetted perimeter), then for a pipe running full $\pi d^2/4 \div \pi d = d/4 = \overline{R}$, so that we may write Equation (17) as follows:

$$v^2 = \left(\frac{8g}{f}\right) \cdot \overline{RS}$$

$$v = c\sqrt{\overline{RS}} \quad \ldots\ldots\ldots\ldots\ldots (23)$$

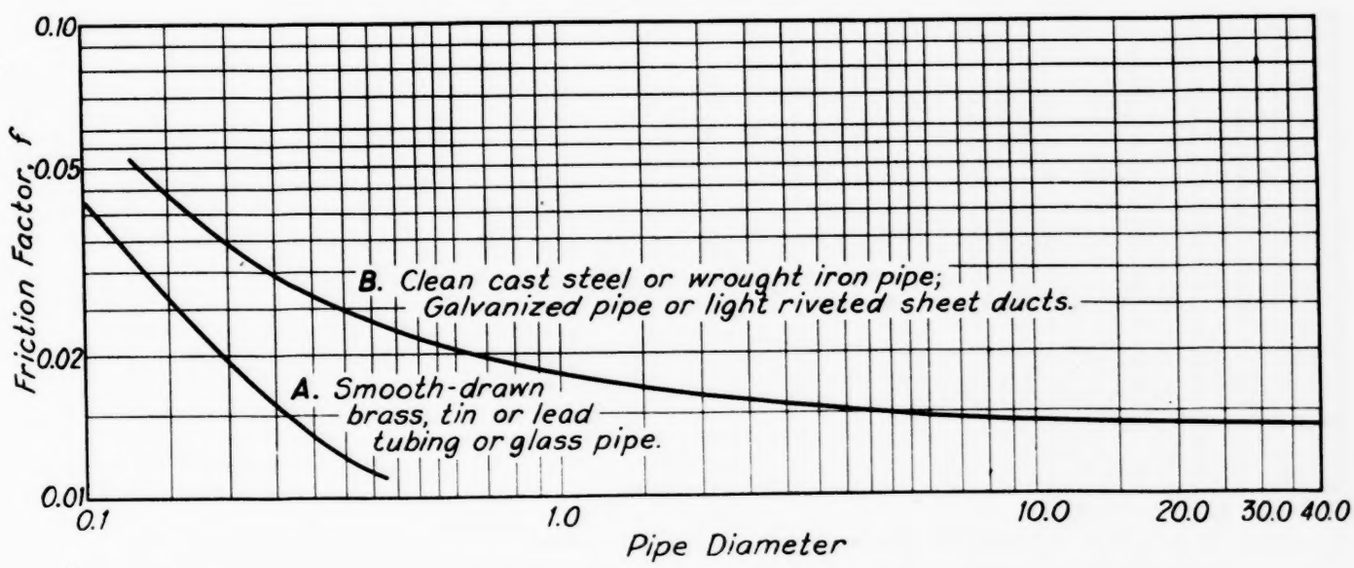


Fig. 8. Average values of friction factor f for various pipe sizes and condition of inner surface.

where c is written for $\sqrt{8g/f}$. In deriving the foregoing equation it is recognized that p and h are equivalent, as they must be. The units of c are clearly $\sqrt{[LT]^{-2}}$, and since the unit of $\overline{R}$ is $[L]$, we see that the equation is dimensionally correct. Since, as we have seen, f does not vary greatly for a given fluid or pipe, we may set up a series of values for c for pipes of different construction. Usual values are $c = 130$ for cast iron pipe and 110 for riveted steel construction. Note the other variants of Equation (23).

$$v = \frac{c}{2}\sqrt{ds} \quad \ldots\ldots (23a)$$

$$v = 0.394 c d^{0.5} S^{0.5} \quad \ldots\ldots (23b)$$

$$S = 1.625\, C^{-2} d^{-5} Q^2 \quad \ldots\ldots (23c)$$

Hazen-Williams Formula. We must now discuss a subject of controversial nature. In nearly all hydraulic experiments it has been shown that the velocity of flow in a pipe does not vary exactly as the half-power of the slope, but as some other power greater than one-half. More generally

$$v = c' d^p s^q \quad \ldots\ldots (24)$$

The question posed is this: Is it preferable to have c vary with velocity and pipe diameter so that v always conforms to Equation (23a), or should we correct this equation to conform to Equation (24), which is experimentally correct, and allow for corrections of c in accordance with the conditions of the pipe? This may be answered as follows: Hydraulicians prefer the form given in Equation (24) while students of fluid flow in general prefer the form given in Equation (23) or its variant Equation (17). As long as the nature of the coefficient c is defined, no difficulty is involved. Certainly Equation (17) with f defined as in Equation (18) connotes greater meaning as to the factors involved. Chezy's formula, Equation (23), is merely a convenient expression of geometric interest. The basis of the present argument, as already stated, lies in the relationship between shape and velocity which from numerous experiments is

$$S = a v^n \quad \ldots\ldots (25)$$

where a and n are constants only as long as the condition and nature of the interior surface do not change.

TABLE 2.—VALUES OF CHEZY'S COEFFICIENT C FOR NEW SMOOTH STRAIGHT PIPES.

Diameter (inches)	Mean velocity (ft per sec)							
	0.5	1	2	3	4	5	10	20
½	78	82	87	90	93	95	101	106
¾	80	84	88	91	94	96	102	106
1	80	85	90	93	95	97	103	106
2	84	88	93	95	97	99	104	107
3	85	90	95	97	99	101	105	108
4	87	92	96	99	100	102	107	110
6	90	94	99	101	103	104	108	111
8	93	97	101	103	105	106	110	113
10	95	99	103	105	107	108	112	114
12	98	101	105	107	109	110	113	116
14	100	103	107	109	110	111	115	117
16	103	105	109	111	112	113	116	118
18	104	107	110	112	114	115	117	119
20	106	109	112	114	115	116	118	120
24	110	113	116	117	118	119	121	123
30	115	118	120	121	122	123	125	126
36	120	123	125	125	126	126	128	130
42	125	127	128	129	130	130	132	133
48	130	131	132	133	133	134	135	137

TABLE 3.—SUMMARY OF RESULTS OBTAINED BY FAIR AND COLLEAGUES FOR VARIOUS PIPES, USING COLD WATER AT TEMPERATURES 36-77F.

Kind of Pipe	Dia. (in.)	Amount of water delivered (cu ft)	C*	N	de/d
Copper	1½	916,000	137-133	1.73-1.79	1.01-0.99
	¾	265,000	154-129	1.73-1.77	1.06-0.99
Red brass	1½	908,000	136-133	1.73-1.77	1.00
	¾	263,000	155-132	1.73-1.77	1.07-1.00
Admiralty metal	1½	901,000	135-129	1.76-1.85	1.00-0.99
	¾	260,000	155-128	1.72-1.75	1.07-0.99
Galvanized steel	1½	941,000	134-126	1.79-1.94	1.03-0.99
	¾	262,000	140-94	1.79-2.00	1.02-0.90
Steel	1½	465,000	135-38	1.79-2.00	1.00-0.66
	¾	124,000	129-24	1.77-2.00	0.99-0.54
Wrought iron	1½	493,000	129-37	1.74-2.00	1.00-0.65
	¾	124,000	138-28	1.76-2.00	1.03-0.57
Galvanized wrought iron	1½	929,000	114-88	1.83-1.98	1.03-0.99
	¾	237,000	109-76	1.86-2.00	0.95-0.88

*Hazen-Williams' or Chezy's C.

Values of n may be as low as 1.7, but never exceed 2.0. The value of a is relatively low for a clean pipe, increasing with n for the same pipe as it deteriorates. On the basis of this experimental observation, Hazen and Williams proposed the equation

$$v = C\overline{R}^{0.63} S^{0.54} \cdot (0.001)^{-0.04} \quad \ldots\ldots (26)$$

or

$$S = 3.02\, C^{-1.85} v^{1.85} \overline{R}^{-1.17}$$

The factor $(0.001)^{-0.04}$ is designed to make the factor C possess the same values as C in Equation (23). Equation (26) is an *average* based on Hazen and Williams' analysis of available data. Values of C for water flowing in pipes of various kinds are shown in Table 2.

Studies by Fair. Perhaps the most complete study of the Chezy coefficient up to the present time was made by Fair, Whipple and Hsiao (1930). These investigators showed that the constant a in Equation (25) is related to the exponent n (for water) as follows:

$$a = \frac{k}{g}\left(\frac{p'}{w}\right)^{n-2} d^{n-3} \quad \ldots\ldots (27)$$

where w is the absolute viscosity, and k is a constant which in turn is a function of n,

$$k = 32\left[2140\left(0.8585 - \frac{2-n}{n-1}\right)\right]^{1-n} \quad \ldots\ldots (28)$$

Thus, knowing n, the relation between s and v is completely determined as long as n *approaches* a value of 2.0. However, a may increase as n just equals 2.0. This means that roughness is not measured by n alone. As pipe roughness increases there is an accompanying decrease in pipe diameter. In other words, there is an alteration in the carrying capacity of the pipe. This may be accounted for by an "effective diameter" d_e given by the expression

$$d_e = \left[\frac{k}{g}\frac{d^{2n}}{a}\left(\frac{p'}{w}\right)^{2-n}\right]^{\frac{1}{n+2}} \quad \ldots\ldots (29)$$

When this value of the diameter is introduced in Equation (25) and v calculated on the basis of the reduced diameter d_e, the values of a for the pipe for any degree of roughness is constant. Solving for d_e/d

$$\frac{d_e}{d} = \left[\frac{k}{g}\frac{d^{-(n-2)}}{a}\left(\frac{p'}{w}\right)^{2-n}\right]^{\frac{1}{n+2}} \quad \ldots\ldots (30)$$

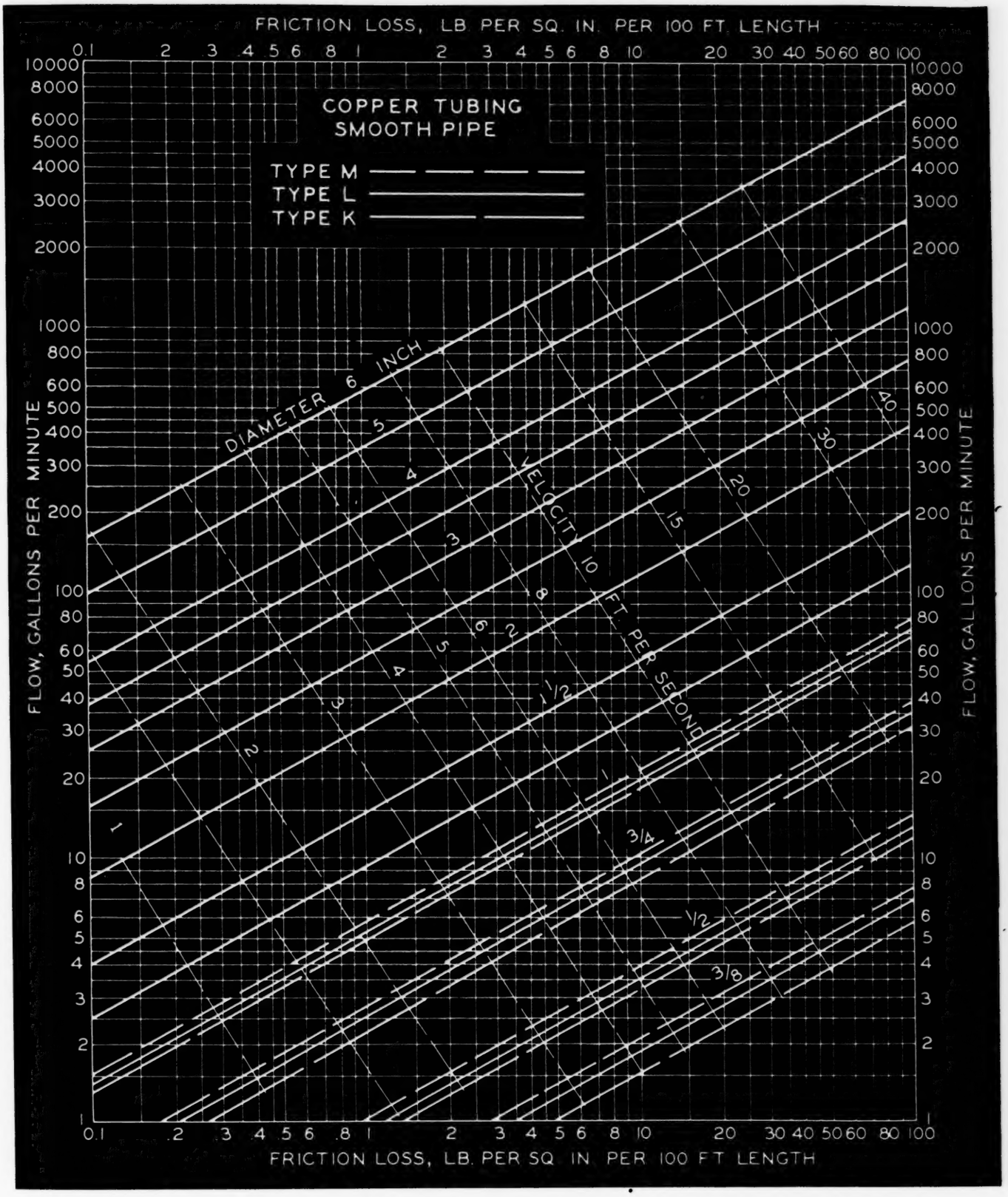


Fig. 9. National Bureau of Standards friction chart for water flowing in smooth tubing with streamlined fittings, designed on the basis of actual copper tubing diameters but with nominal sizes indicated. This chart can also be used for brass pipe (I.P.S.) with recessed fittings by taking into account differences in diameters.

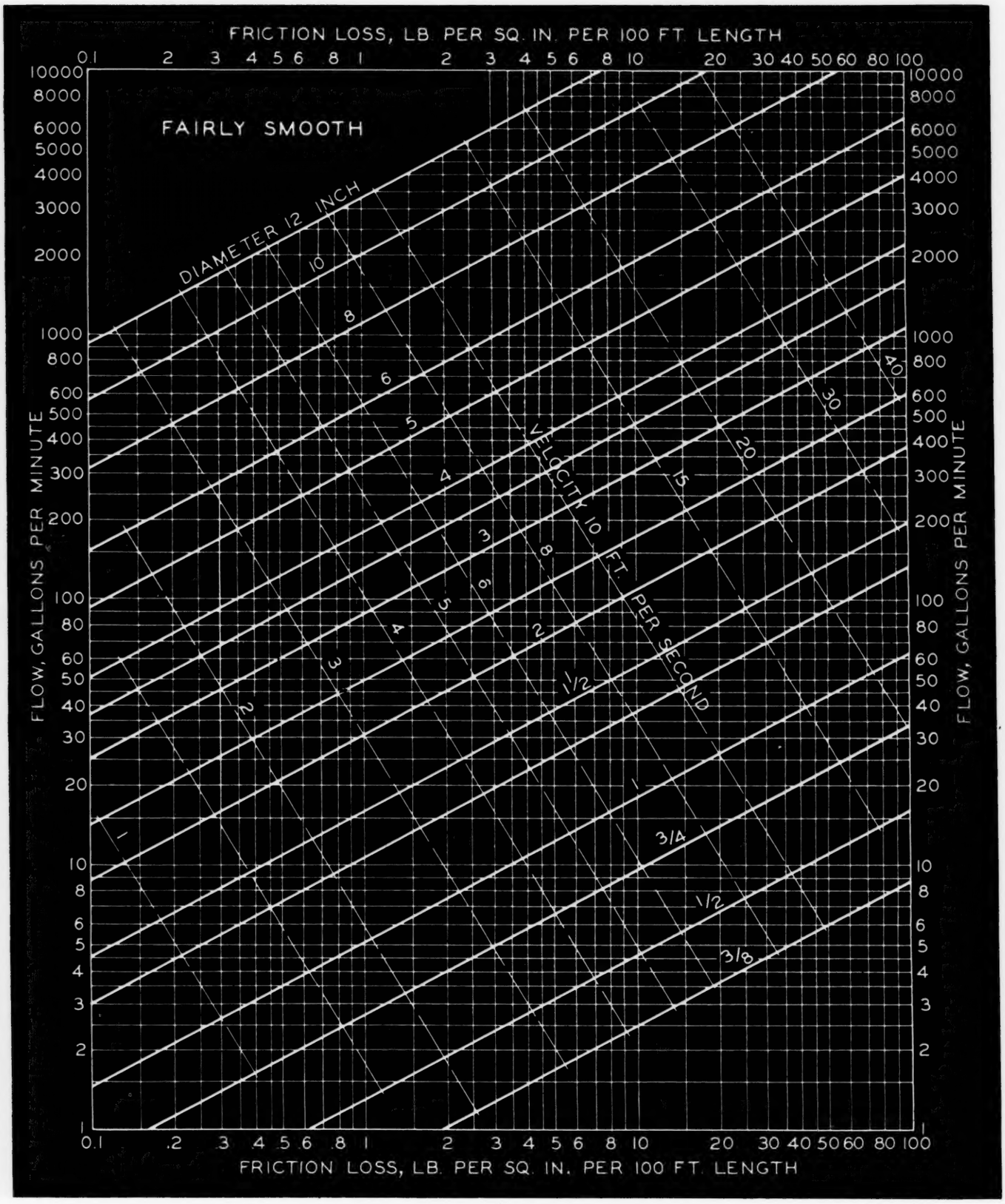


Fig 10. Friction chart for new steel or wrought iron pipe, designed by the National Bureau of Standards for water piping.

which is the fractional change of d with change of n and a simultaneously.

The investigations of Fair and his colleagues were conducted with pipes ranging from ¾ inch to 1½ inches in diameter and were composed of copper, red brass, admiralty metal, steel, and wrought iron. All tests were made with water at temperatures 36 to 77F and 140F. The studies were extended over a period of three years and are perhaps the most comprehensive ever made in which the changes in the variables were observed continuously. Obviously, the changes noted apply to the particular water used, since it is known that deterioration in pipes depends upon its chemical nature. Nevertheless, they bear out the fundamental considerations outlined above. Some of the data obtained are given in Tables 3 and 4.

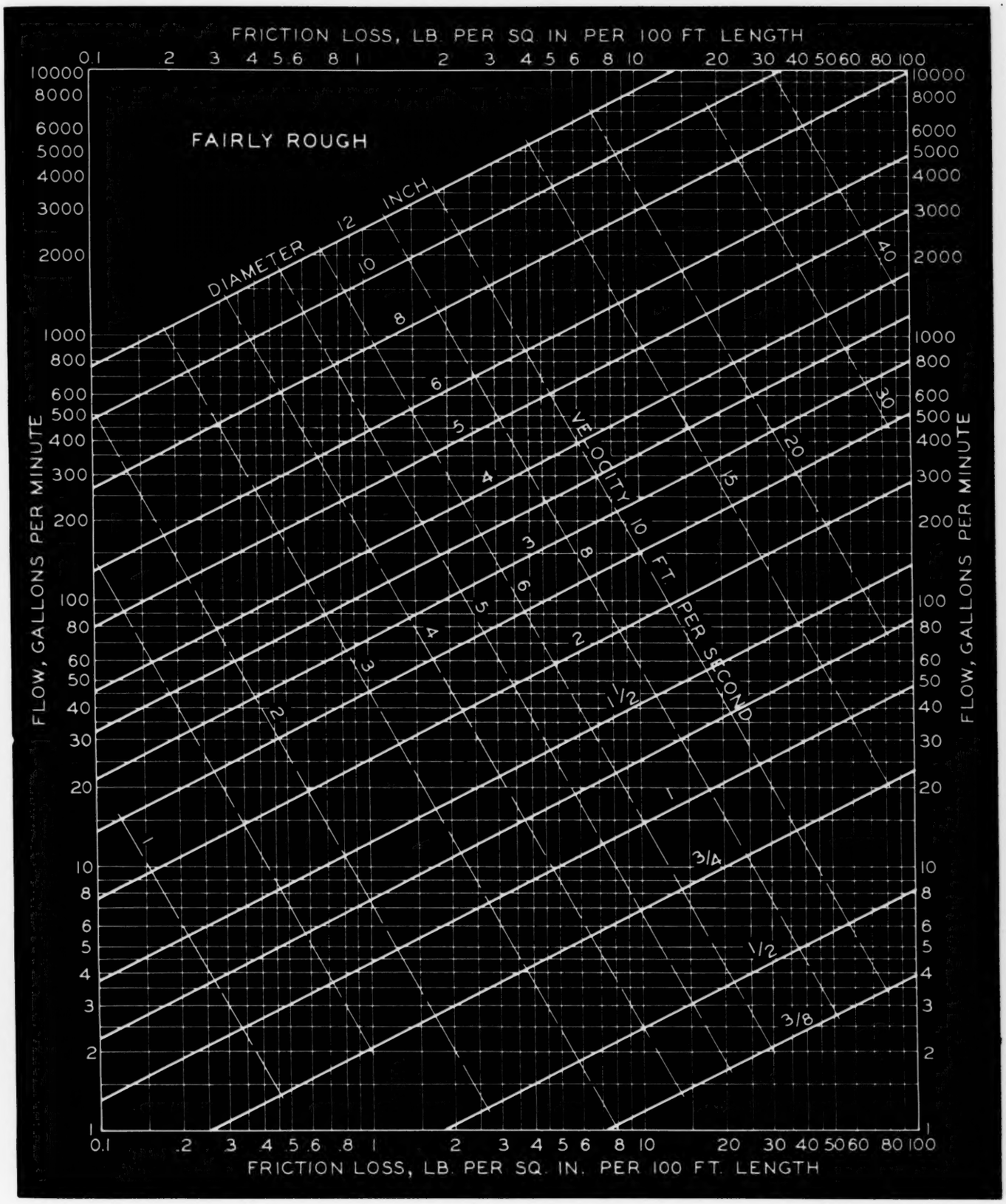


Fig. 11. It is assumed that ferrous pipe after a few years' service with the best of waters will have passed from the Fairly Smooth class to the Fairly Rough class, provided for on the above chart of the Bureau of Standards series.

It may be seen from these tables that for copper, red brass, and admiralty metal, values of n change but slightly and values of d_e/d scarcely at all, the limits being 1.00 ± 0.01. On the other hand, the variation of these constants is considerable in the case of steel and wrought iron pipes. The results may be summarized in the following equations. For water at normal temperatures in copper, red brass, and admiralty metal pipes

$$\begin{cases} s = av^{1.754} \\ a = 0.00495 \left(\dfrac{p^3}{w}\right)^{0.246} d^{-1.246} \end{cases} \quad \ldots\ldots\ldots (31)$$

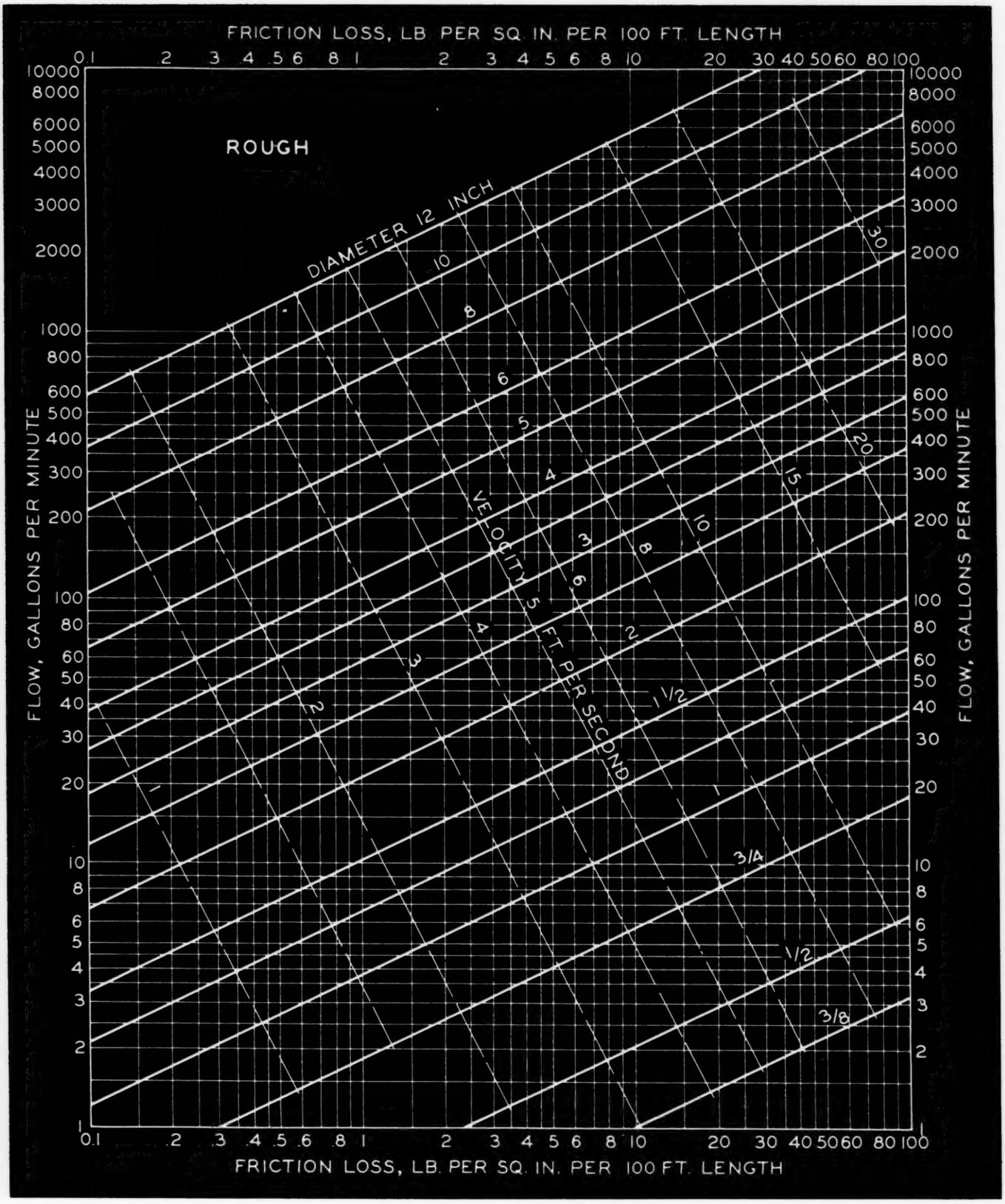


Fig. 12. It is assumed that ferrous pipe, after a few years' service with badly corrosive or caking water, will pass from a Fairly Smooth to a Rough category, covered by the above chart of the Bureau of Standards series. Resulting change in diameter should be estimated and taken into account. Ordinarily the drop in capacity with hard water will be greater in (1) small sizes than in larger, and (2) in hot water lines than in cold water lines.

For galvanized steel and wrought iron pipes

$$\begin{cases} s = av^{1.88} \\ a = 0.0016 \left(\dfrac{p'}{w}\right)^{-0.12} d^{-1.12} \end{cases} \quad \ldots\ldots\ldots (32)$$

Example. If at 60F, $p' = 62.3$ lb per cu ft and $w = 0.000766$ FPS-units, calculate the flow in gallons per minute from Equation (32):

Solution. (1) From Equation (32)

$$v = a^{-\frac{1}{1.88}} S^{\frac{1}{1.88}} = a^{-0.53} S^{0.53}$$

$$(2) \qquad a = 0.0016 \times \left(\frac{62.3}{0.000766}\right)^{-0.12} d^{-1.12}$$

$$= 0.0016 \times 0.258 \times d^{-1.12} = 0.000413 d^{-1.12}$$

$$a^{-0.53} = (0.000413)^{-0.53} d^{0.59} = 63.0 d^{0.59}$$

$$v = 63.0 d^{0.59} S^{0.53}$$

(3) Since $v = Q/A$ and expressing d in inches

$$Q = 63.0 \frac{\pi D^2}{4 \times 144} \times \left(\frac{D}{12}\right)^{0.59} S^{0.53} \quad \text{(cu ft per sec)}$$

$$Q = 0.08\ D^{2.60}\ S^{0.53} \quad \text{(cu ft per sec)}$$

(4) Since 1 cu ft = 7.48 gal, the flow G in gpm is

$$G = 0.08 \times 60 \times 7.48\ D^{2.60}\ S^{0.53}$$

$$= 35.9\ D^{2.60}\ S^{0.53} \text{ gal per min}$$

Blasius' Formula. The following formula, due to Blasius, is widely used in European hydraulic practice

$$\frac{p}{l} = 0.0116\ w^{0.25}\ p'^{0.75}\ v^{1.75}\ d^{-1.25} \quad \ldots\ldots\ldots (33)$$

With the exception of the constant terms, this equation bears a close resemblance to Equation (31). At 70F, and using the data given in the example above

$$\frac{p}{l} = 0.0435 v^{1.75}\ d^{-1.25}$$

$$S = 0.0007 v^{1.75}\ d^{-1.25} \quad \ldots\ldots\ldots (34)$$

The value of S deduced from Blasius' equation is twice as high as that computed from Equation (31). The fact that the v's and d's correspond is of interest inasmuch as the work of Blasius antedates that of Fair and his colleagues by about 20 years.

National Bureau of Standards Formulas. The National Bureau of Standards (1941) recommended a four-fold classification of pipes. These are as follows:

Class 1. Smooth pipe, including copper or brass tubing, with streamline fittings;

Class 2. Fairly smooth pipe, including butt-welded steel and wrought iron pipe with threaded fittings;

Class 3. Fairly rough pipe or a degree of roughness between fairly smooth and rough pipe; and

Class 4. Rough pipe, including any kind of badly corroded or badly caked pipe.

The following formulas were proposed for each of these classes:

Class 1:

$$\frac{h}{l} = 0.00682\ v^{1.75}\ D^{-1.25} \quad \ldots\ldots\ldots (35)$$

Class 2:

$$\frac{h}{l} = 0.0073\ v^{1.83}\ D^{-1.17} \quad \ldots\ldots\ldots (36)$$

Class 3:

$$\frac{h}{l} = 0.008\ v^{1.92}\ D^{-1.08} \quad \ldots\ldots\ldots (37)$$

Class 4:

$$\frac{h}{l} = 0.0101\ v^{2}\ D^{-1} \quad \ldots\ldots\ldots (38)$$

In these formulas h and l are in feet, v in ft per sec, and D in inches. Figs. 9 to 12, from the Bureau of Standards, show the pressure loss in pounds per square inch per 100 ft of pipe based on the above equations.

(In a subsequent section there will be presented applications of the theory here discussed, including the flow of liquids and gases in pipes and ducts.)

TABLE 4.—SUMMARY OF RESULTS OBTAINED BY FAIR AND COLLEAGUES FOR VARIOUS PIPES USING WATER AT 140F (Pipe diameter ¾ in.)

Kind of Pipe	Amount of Water delivered (cu ft)	c*	n	de/d
Copper	94,000	132-128	1.69-1.75	1.00-0.99
Red Brass	14,000	132	1.74-1.75	1.00
Admiralty metal	13,000	133-132	1.72-1.75	1.00
Galvanized steel	8,000	117-91	1.98-2.00	0.92-0.89
Steel	3,000	124-9	1.89-2.00	0.96-0.37
Wrought iron	3,000	122-6	1.77-2.00	0.96-0.31
Galvanized wrought iron	31,000	109-76	1.90-2.00	0.91-0.83

*Hazen-Williams' or Chezy's coefficient.

Experience with Water Hammer

By JOHN J. WOOLFENDEN

Engineering Staff, Smith, Hinchman & Grylls, Inc., Architects and Engineers, Detroit, Mich.

MANY engineering students, and many who are beyond the student stage, talk knowingly about water-hammer, its maximum value and its effects; but how many of them have ever seen a really severe case of it or the results of such an occurrence, and actually realize what it is like? It is so easy to produce and, in a very minor form, so common in heating systems and in water piping, that its destructive potentialities are often lost sight of.

One of the simplest ways to produce it in what may be a very dangerous form is to admit steam too rapidly into a cold piping system, nor does the steam need to be at particularly high pressure to produce disastrous results.

A few years ago, the writer happened to see an operator admit steam rapidly into a system through an eight-inch main, some seventy or eighty feet long, with a 90 degree elbow about sixty feet "downstream" from the valve. Within much less than a minute after the valve was opened, the back was blown out of the elbow—and the steam pressure was not over 30 lb gauge. Fortunately, no one was injured.

To illustrate how little apparent, or static, pressure may be indicated and yet a very respectable water hammer be produced, let us consider the case of a centrifugal pump that went to the junk pile nearly thirty years ago—at least the casing did.

The discharge pipe was about three hundred fifty feet long, and pitched upward *less than four feet* in that direction. The pump discharged vertically upward and was connected to the horizontal line by approximately two feet of pipe. The pump took its suction from a tank, some three feet away, through a 4-in. pipe with a check valve at the pump. The discharge line was 3 in. in size and was without check valve.

The pump was of the horizontal open impeller type, direct-connected to an electric motor and was provided with automatic control, the starter being actuated by a float switch in the tank. The substance handled was sewage, which has about the same specific gravity as water.

When the pump operated, it imparted motion to the liquid in the discharge line, giving it a velocity theoretically equal to the peripheral velocity of the impeller, but actually somewhat less. When the current supply was cut off, however, the impeller, due to brake action, friction and other retarding influences, would slow down more rapidly than the liquid in the discharge line lost its motion and hence would, so to speak, exert a negative influence, since the flow of water through it would tend to decrease as the speed diminished.

True, the motion of the liquid in the discharge line would tend to pull water through the impeller, but nevertheless, its action being negative, relatively, the result would be a partial vacuum.

The check valve would be actuated by the flow of water and, when the flow was reduced to the critical point, would close.

Since the quantity of liquid delivered by a centrifugal pump varies as the peripheral velocity of the impeller, and since the velocity of the liquid in the discharge line is also approximately equal to this peripheral velocity, the resulting vacuum at any moment would be some function of the difference between the velocity of liquid in the discharge pipe and the peripheral velocity of the impeller or, roughly speaking, a function of the change in impeller speed.

The effective vacuum would be decreased by the effect of the static head, due to the influence of gravity, which will act to bring the fluid to rest more quickly.

Therefore it follows, paradoxical as it may seem, that in the case of horizontal or near-horizontal piping, the less the static head and the longer the discharge line (i.e., the greater the momentum of the liquid) the greater will be the tendency to produce a vacuum and, hence, the more severe the resulting water hammer. Pitching the discharge line downward from the pump might be thought to tend to reduce the back-kick, but the effect would depend upon the degree of vacuum produced and the destructive results would not necessarily be eliminated; in fact, there are, conceivably, conditions such that the tendency to increase the vacuum might do more harm than good.

Were the discharge pipe entirely vertical, the weight of the liquid, itself, would tend to cause it to "push back" on the impeller, and respond more readily to changes in impeller speed. Hence any change in impeller speed would be quickly followed by a change in the liquid velocity and this, in turn, would mean that, when the impeller approached the stopping point, the liquid would have lost much of its initial velocity; the impact, or water hammer, consequently would be correspondingly reduced.

To return to our pump. The weight of liquid in the discharge line was about 1100 lbs. Were the liquid to have a velocity of, say, 3 fps or about one-fourth of that imparted by the pump impeller, as the writer recalls the rate of flow in the line, the momentum would be approximately 103 foot-pounds and the energy about 154 foot-pounds. With the foot valve closed, assuming that the splitting of the casing resulted from the initial impact and represented a motion of, say, about ¼ in. on the average, the average resulting force acting on the casing would be well over 6000 lb and the equivalent maximum tension might be as much as 12000 lb.

Graphical Determination of Heat Transfer Film Coefficient for Liquid Freon-12†

B. F. RABER* and F. W. HUTCHINSON**

THIS article in the series on heat transfer film coefficients presents graphical solutions for convective heat exchange between liquid Freon-12 and the pipe in which, or around which, it is flowing. As with the other corresponding sets of graphs which have appeared in this series, the solution given for Freon-12 flowing inside a pipe has two sets of temperature lines, one for use when the fluid is being heated and the other set for fluid which is cooling. The solution for flow outside and normal to a single pipe has but one set of temperature lines since the coefficient is practically the same, for this case, whether the fluid is heating or cooling. The graphs should not be used for velocities lower than 1 foot per second.

Two striking differences are noted between the graphical solutions for Freon-12 and the solutions which have already been given for other liquids: (1) The film resistance is substantially greater in the case of Freon-12; (2) The film coefficient decreases with increasing temperature of the fluid. In using the coefficients given here for solving design problems it must be remembered that these values are for the pure refrigerant; the presence of oil in the fluid will materially change the film resistance. Adequate data are not yet available to warrant quoting correction factors to take into account the effect of admixed lubricating oil.

Completing the tabulations of thermal resistances of standard copper tubing (Tables 2 and 3 for Types K and L appeared in February and March) Table 4 for Type M copper tubing is included.

Problem: Freon-12 at a temperature of 75F is flowing at 8 feet per second in a 2 inch nominal diameter Type M copper tube. The liquid to which the tube is losing heat is Freon-12 at 0F which is flowing normal to the tube at a velocity of 6 feet per second. (I.D. and O.D. of 2 in. Type M are 2.009 in. and 2.125 in., respectively.) Determine the rate of heat transfer per lineal foot of tube.

Solution: The inside film coefficient is found by following the dashed line on Fig. 9 and reading $h_i = 420$ Btu per hr per sq ft per F. Then enter Table 4 at this value of h, move horizontally over to the r_i column for 2 inch tubing and interpolate to find .00456 as the inside film resistance per lineal foot of pipe. The outside film coefficient is determined from Fig. 10 by following the dashed line, as shown, and reading $h_o = 260$ Btu per hr per sq ft per F. Then, entering Table 4 at $h = 260$ and moving horizontally over to the r_o column for 2 inch tubing, interpolate to find .00761 as the outside film

†Similar articles on water, ammonia, sulfur dioxide, and brine appeared in the December, 1944, and the January, February and March, 1945, issues of HEATING AND VENTILATING.

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**Associate Professor of Mechanical Engineering, University of California, Berkeley.

NOTE: Freon is a copyrighted trade name held by the Kinetic Chemicals Company.

TABLE 4.—THERMAL RESISTANCES PER LINEAL FOOT OF TYPE M COPPER TUBING

(r_i = Inside film resistance; r_p = pipe wall resistance; r_o = outside film resistance; h = film coefficient of heat transfer from charts)

Material	Nominal Outside Diameter of Tube, Inches (*Actual O.D. ⅛ inch greater than nominal*)																			
	¼		½		¾		1		1½		2		2½		3		3½		4	
	Values of r_p																			
P.Cu.[1]	.000121		.0000797		.0000646		.0000546		.0000528		.0000477		.0000431		.0000401		.0000398		.0000401	
h	r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o
50	.235	.204	.1134	.122	.0940	.0874	.0724	.0678	.0500	.0472	.0380	.0360	.0306	.0291	.0256	.0244	.0221	.0211	.0194	.0185
100	.117	.102	.0672	.0610	.0470	.0437	.0362	.0339	.0250	.0236	.0190	.0180	.0153	.0145	.0128	.0122	.0110	.0105	.00972	.00927
200	.0588	.0509	.0336	.0305	.0235	.0219	.0181	.0170	.0125	.0118	.00951	.00900	.00765	.00727	.00641	.00611	.00552	.00527	.00486	.00463
300	.0392	.0336	.0224	.0203	.0157	.0146	.0121	.0113	.00834	.00785	.00634	.00600	.00510	.00485	.00427	.00407	.00368	.00352	.00324	.00309
400	.0294	.0255	.0168	.0153	.0118	.0109	.00905	.00847	.00625	.00589	.00475	.00450	.00383	.00364	.00321	.00306	.00276	.00264	.00243	.00232
500	.0235	.0204	.0134	.0122	.00940	.00874	.00724	.00678	.00500	.00472	.00380	.00360	.00306	.00291	.00256	.00244	.00221	.00211	.00194	.00185
600	.0196	.0169	.0112	.0102	.00785	.00728	.00603	.00565	.00417	.00392	.00317	.00300	.00255	.00242	.00214	.00204	.00184	.00176	.00162	.00154
700	.0168	.0145	.00960	.00871	.00672	.00623	.00517	.00485	.00357	.00336	.00272	.00257	.00218	.00208	.00183	.00175	.00158	.00151	.00139	.00132
800	.0147	.0127	.00840	.00763	.00588	.00545	.00452	.00424	.00313	.00294	.00238	.00225	.00191	.00182	.00160	.00153	.00138	.00132	.00121	.00116
900	.0131	.0113	.00747	.00677	.00523	.00485	.00402	.00377	.00278	.00262	.00211	.00200	.00170	.00162	.00142	.00136	.00123	.00117	.00108	.00103
1000	.0117	.0102	.00672	.00610	.00470	.00437	.00362	.00339	.00250	.00236	.00190	.00180	.00153	.00145	.00128	.00122	.00110	.00105	.000972	.000927
1100	.0107	.00925	.00611	.00555	.00427	.00395	.00329	.00308	.00228	.00214	.00173	.00163	.00139	.00132	.00116	.00111	.00100	.000959	.000884	.000843
1200	.00980	.00848	.00560	.00508	.00392	.00364	.00302	.00282	.00208	.00196	.00158	.00150	.00127	.00121	.00107	.00102	.000921	.000879	.000810	.000772
1300	.00904	.00733	.00517	.00469	.00362	.00336	.00278	.00261	.00192	.00181	.00146	.00138	.00118	.00112	.000986	.000940	.000850	.000811	.000747	.000714
1400	.00840	.00726	.00480	.00436	.00336	.00312	.00258	.00242	.00178	.00168	.00136	.00128	.00109	.00104	.000915	.000873	.000789	.000754	.000694	.000661
1500	.00784	.00679	.00448	.00406	.00314	.00290	.00241	.00226	.00167	.00157	.00127	.00120	.00102	.000971	.000855	.000815	.000736	.000703	.000648	.000618
1600	.00735	.00635	.00420	.00381	.00294	.00272	.00226	.00212	.00156	.00147	.00119	.00112	.000956	.000910	.000801	.000764	.000690	.000659	.000607	.000579
1700	.00691	.00599	.00396	.00359	.00276	.00256	.00213	.00199	.00147	.00138	.00112	.00106	.000900	.000857	.000754	.000719	.000650	.000620	.000571	.000545
1800	.00653	.00565	.00373	.00339	.00261	.00242	.00201	.00188	.00139	.00131	.00106	.00100	.000850	.000810	.000712	.000679	.000614	.000586	.000540	.000515
1900	.00619	.00535	.00354	.00321	.00248	.00230	.00190	.00178	.00132	.00124	.00100	.000947	.000805	.000766	.000675	.000644	.000581	.000555	.000521	.000488
2000	.00588	.00509	.00336	.00305	.00235	.00219	.00181	.00170	.00125	.00118	.000951	.000900	.000765	.000727	.000641	.000611	.000552	.000527	.000486	.000463

[1]Phosphorized copper.

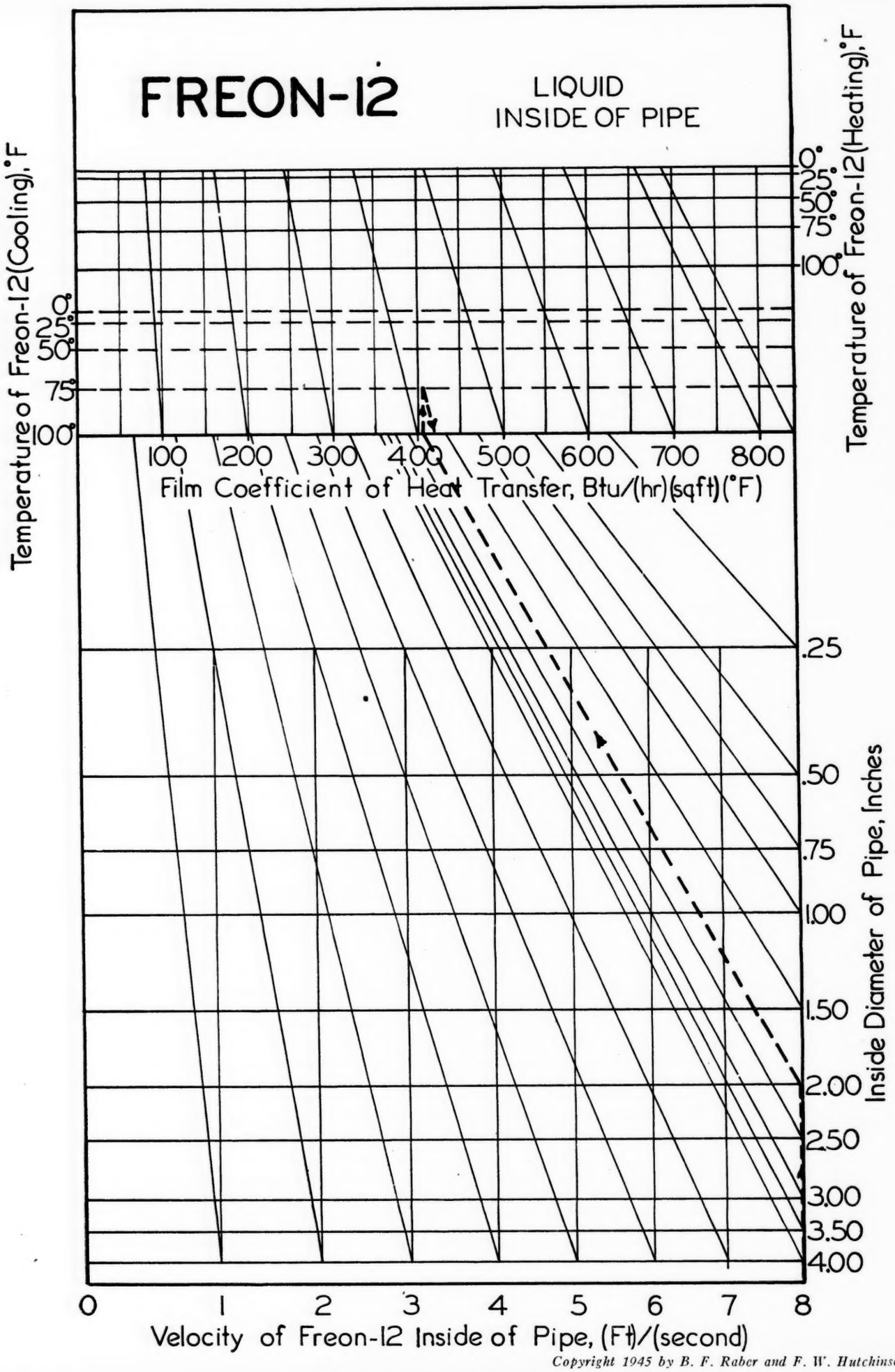

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Fig. 9. Film coefficient for liquid Freon-12 flowing inside a pipe.

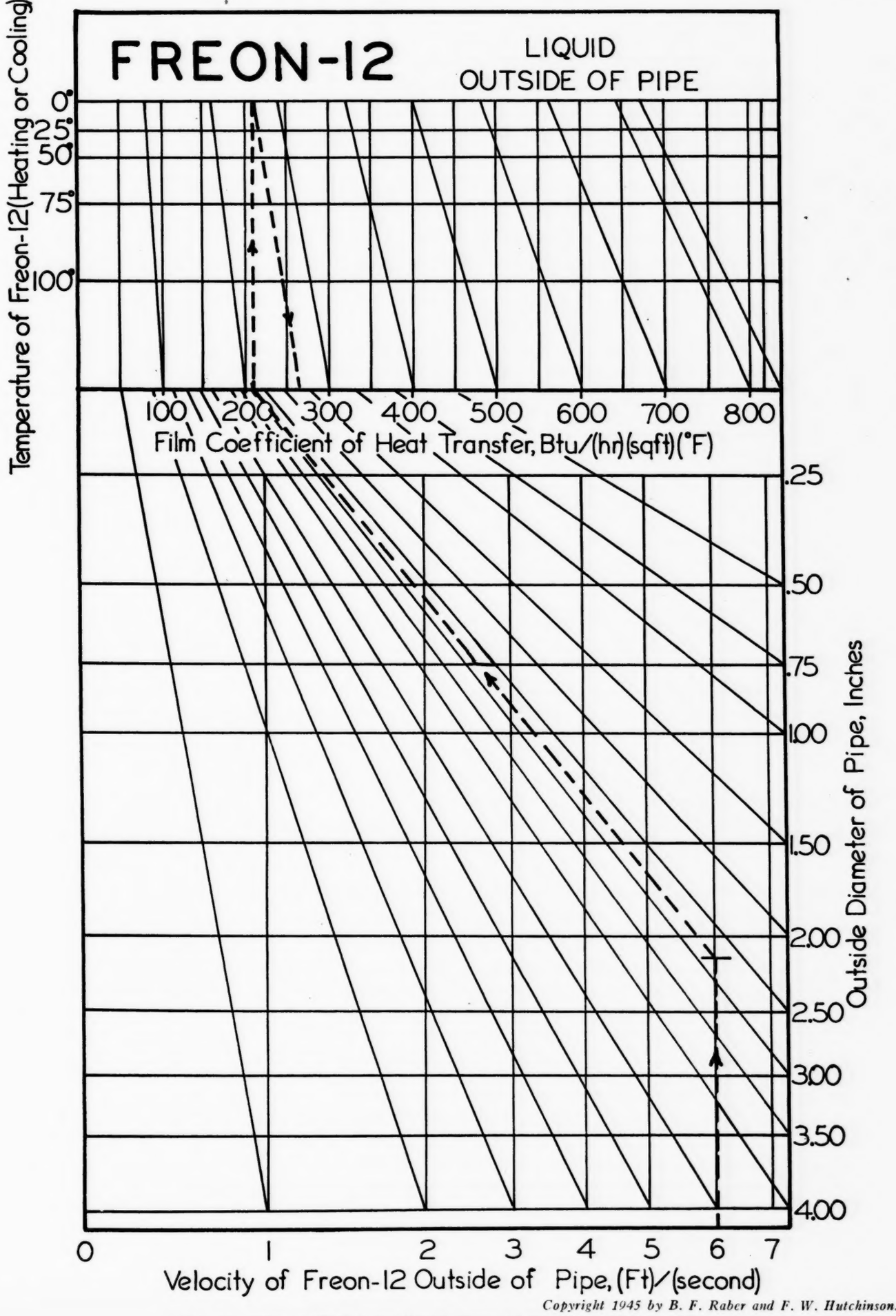

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Fig. 10. Film coefficient for liquid Freon-12 flowing outside a pipe.

resistance per lineal foot. From the table, the wall resistance of 2 inch tube is found as .0000477. The total resistance from fluid-to-fluid is therefore $R = .00456 + .0000477 + .00761 = .01222$, the heat transfer rate is $(t_h - t_c)/R = (75, -0)/.0122 = 61.5$ Btu per hour per lineal foot of tube.

WHAT OUR READERS SAY

Copper Tubing

EDITOR, HEATING AND VENTILATING:

There are certain statements in the excellent article entitled "Graphical Determination of Heat Transfer Film Coefficient for Sulfur Dioxide" by Raber and Hutchinson appearing in your February issue that indicate an apparent misunderstanding on the part of the authors which may also exist on the part of some of your readers with reference to commercial designations for different types of copper tube. This misunderstanding is probably due to the manufacturers' failure to give proper publicity to the correct designations of their products.

The first sentence of the article states that the graphs and tabulation give film coefficients and wall resistances for "Type K Standard Tubing".

The problem in the right hand column of the first page of the article refers to heat exchange "occurring through ¾ in. (nominal) diameter Type K admiralty metal standard tubing".

A natural inference from the two quoted references, as well as from the tabulation, would be that Type K Standard Tubing is available in all the materials listed, whereas such is not the case.

Letter designations applying in general to copper tubing originated in Federal and A.S.T.M. Specifications and are used in our industry with specific significance. For example, the designations Type K, Type L, and Type M apply only to phosphorized copper tube made to the schedule of sizes given under Federal Specification WWT-799 and ASTM Specification B-88. The outside diameter of the tube is in each case ⅛ in. greater than the nominal size. This is not true in the case of any alloy tubing.

Because of the above, therefore, tube made from the alloys listed under the tabulation should not be referred to as Type K, except in the case of phosphorized copper. Types K, L, and M copper tubes being made only in standard sizes, are normally carried in stock by the mills and by wholesalers of plumbing and heating supplies. Alloy tube, on the other hand, is generally furnished on contract order to specified O.D. and wall thickness, or I.D. and wall thickness subject to published commercial tolerances. Types K, L, and M are used principally for plumbing work and low pressure heating systems and are seldom used for heat exchange devices.

While the data given in the tabulation are of considerable practicable value to design engineers it is important that no misunderstanding should exist as to correct designations for different types of tubing. In a case of heat exchange devices, the thermal conductivity of the tube material is not always the deciding factor in its use and I believe it is safe to say that tubes made of some of the alloys listed in the tabulation would seldom be used for conveying sulfur dioxide.

D. L. Mills

Revere Copper and Brass Incorporated, Rome, N. Y.

Dust Filters as Grease Traps

EDITOR, HEATING AND VENTILATING:

Prof. S. F. Duncan's article "Test of Dust Filters Used as Grease Trap" (February issue) is a splendid contribution to the subject of collecting grease entrained in air. Of particular interest are his findings with respect to increased efficiency of the filter with increased air velocity.

Lest there be those who may misinterpret his statement, we would like to point out that, as far as grease arrestance is concerned, the only important air velocity is that through the orifices of the filter itself. This bears no relation to the air velocity in the duct or to the face velocity of the filter.

The velocities shown in Prof. Duncan's chart are face velocities and apply to one particular make of filter. They in no way indicate that 600 feet per minute face velocity is even desirable in connection with other types of grease filters.

This becomes very important when the grease holding capacity of a filter is considered. Obviously, the higher the face velocity, the greater is the volume of grease to which the filter is subjected and the more rapid increase in static resistance. Given equal arrestance efficiencies and areas, the filter operated at a higher *face velocity* will load up faster and require more frequent servicing than the filter with a lower face velocity, for the simple reason that the former has been subjected to more grease-laden air. And, we point out, the arrestance efficiency of the two types of filters may be equal because the air velocities through the orifices of each can be equal.

It should be emphasized that when the ventilating engineer is considering the use of grease filters, he should not confuse face velocities with orifice velocities in determining efficiences but depend on the filter manufacturer's recommendations. He should also give careful consideration to the operating life of the filter before servicing is required.

W. B. Watterson

Air-Maze Corp., Cleveland, Ohio

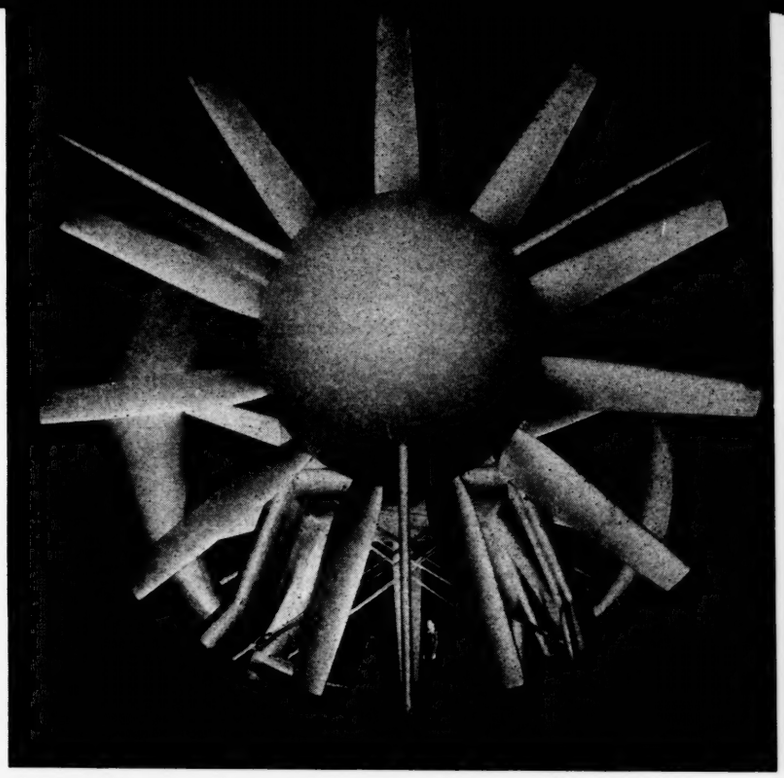
Study Peat Deposits

Minnesota is studying the potentialities of its 5000 acres of peat deposit, believed to represent half of the peat in the U. S. The investigation is being conducted by the Iron Range Rehabilitation & Resources Commission, which has allotted $22,500 for the construction of a peat process plant and laboratory near Duluth.

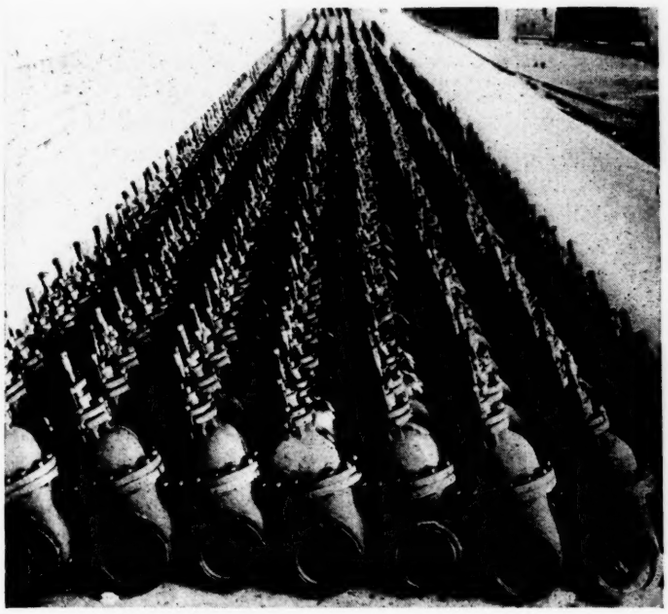
Although peat has been little used in this country as a fuel, it accounts for 25% of all the fuel used in Russia. Many peat-chemical plants have been built in the Soviet Union producing ammonia, acetic and carbolic acids, creosols, and high calorie gas.

Under present conditions peat cannot compete in the U. S. with the plentiful high grade fuels.

Picture Paragraphs

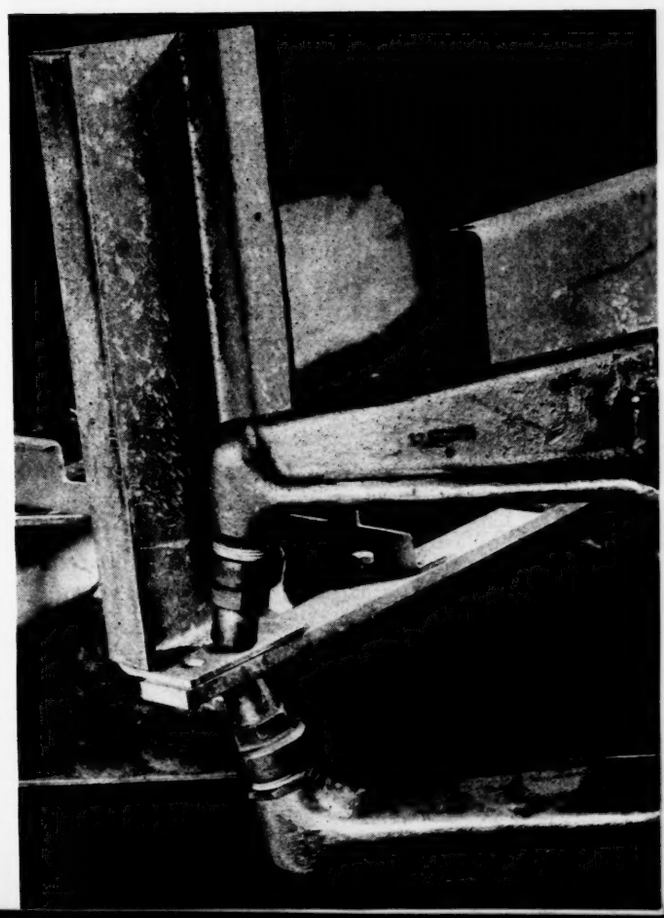


Propeller drive system in the 16 ft wind tunnel in the Ames Aeronautical Laboratory of the National Advisory Committee for Aeronautics at Moffett Field, Calif. The 27,000 hp fan drive is operated by two 13,500 hp G.E. motors operating at 300 rpm. Downstream view is shown.

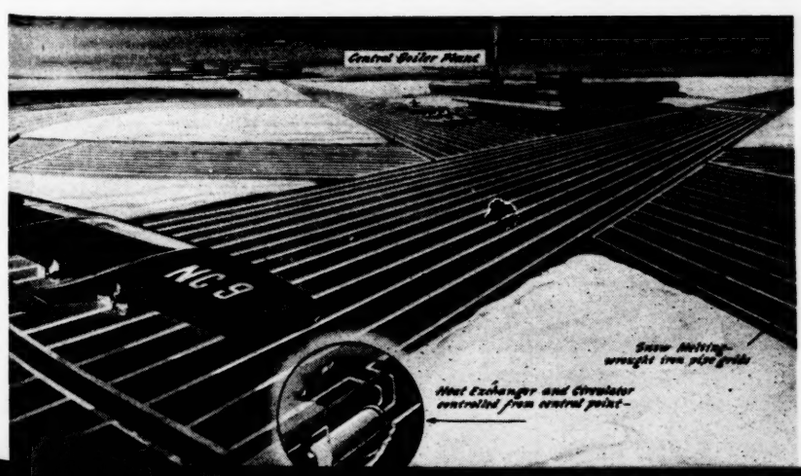


Lined up on this loading dock are Crane valves for gasoline and oil supply pipe lines on the European battle front. Light, thin steel plate pipe is used with demountable couplings and special gaskets so that pipe coupling is simplified for speedy assembly. Mains are laid on the ground as the front line is no place for digging ditches.

A gun welder for spot brazing large copper sections was developed by Westinghouse engineers at the East Pittsburgh plant. Recirculated water is used to cool the molybdenum tips on the welder.



Looking ahead, here is an artist's conception of an aviation field of the future employing an underground radiant heating system to clear runways from snow. One boiler plant could care for all the runways. The central boiler plant is shown in the background; the heat exchanger and circulator controlled from a central point, in the insert; underneath the runways are the pipe grids.



Gasoline Piping and Storage

HARRY D. UNWIN
Mechanical Engineer, Albert Kahn Associated Architects and Engineers, Inc.

PART 4

THERE are four definite phases to be considered in adopting a particular method of handling fluid materials, or in fact in any distribution system:—(1) planning, (2) installation, (3) operation, and (4) maintenance. Experienced engineers are called upon to do the planning and supervise the construction of the system; trained personnel is placed in charge of the operation of the system, but what about the maintenance engineer? He is the man who is called in when something goes wrong and fear of a shut-down of the system is impending. He is concerned not with the design data which say that 100 gpm can be delivered through a 3 in. or 4 in. pipe 1000 feet long if sufficient force is applied; he is concerned with and held responsible for maintaining the equipment necessary to produce this result.

Location of Valves and Controls

Valves, controls, electrical starters, etc., are usually located for the convenience of the operator, but it does not always follow that such location is desirable when service or repairs are necessary. In order to reduce the overhead of maintenance, much can be gained by the maintenance engineer going over the plans as he will analyze the system from his viewpoint which is very different from that of the process engineer or operator and oftentimes can point out minor changes which will save considerable time and expense later on when the system requires attention due to continuous or severe operating conditions.

It is a fallacy to believe that there is sufficient accessibility because the pumps, piping, valves, fittings and accessories were able to originally be installed as shown on the plans. If failure occurs and loss of production results while repairs or replacements are being made, the maintenance force is working against valuable time which could be minimized if service accessibility had been given the same importance as operating accessibility. For example, relief valves on positive displacement pumps should always be installed so that they may be serviced without dismantling of the pump; lubricated plug cocks should be located so that the stick lubricant can be easily renewed; unions, flanged connections, or both should be provided at all pumps so that the pump can be replaced without the need of dismantling an excessive amount of pipe, strainers, valves, etc. A well-built pump is a rugged piece of equipment; nevertheless, it should not be used as a pipe support. The strain placed on the pump by improperly supported piping may break cast connections or produce misalignment causing vibration and excessive wear.

The maintenance engineer, or master mechanic, as he was called in the old days, cannot wait for "business" to come his way. He should be constantly on the lookout for trouble. Through systematic inspection schedules he can anticipate approaching equipment failure and make provision for its repair or replacement during a shut-down period so as not to halt production. When the records are written of the production schedules which have been achieved, much credit must be given to the maintenance man for his part in keeping the equipment running.

Location of piping to avoid mechanical injury is an important factor in preventive maintenance. The installation of high water alarms for sump pumps is another example. Failure of the pump to eject the water may merely indicate a clogged suction which could lead to more serious trouble if not relieved. Gauges, properly located, will show existing pressures throughout a distribution system, or when placed on suction lines will indicate the vacuum being created by the pump. By maintaining a schedule of inspection and recording of the gauge readings any exceptional deviation from the design conditions can be determined and the cause investigated, thereby preventing the development of possible serious complications.

System Safeguards

Adequate ventilation is doubly important where volatile liquids are handled. Pump houses and rooms in which gasoline is dispensed must always be ventilated to prevent the accumulation of inflammable vapors. Natural draft ventilation is sufficient for small isolated, exposed pump rooms above grade. Louvered openings at floor level should be provided since the vapors are heavier than air. For large areas and basements mechanical ventilation by fans is essential. These should provide for the intake of fresh air from outdoors and the exhaust of air from registers at floor level. Ten to fifteen air changes per hour is recommended practice for dispensing rooms; a somewhat smaller movement of air is permissible for segregated pump houses. The electrical equipment must be explosion-proof in accordance

Part of a Series of Articles on Process Piping in Industrial Plants

with the National Electrical Code for Class I, Group D, Locations; and in addition, the exhaust fan must be of spark-proof construction since inflammable vapors will pass through its housing.

Distribution mains should preferably be buried for outdoor piping because of less possibility of mechanical injury. A second reason is that outdoor overhead piping is subject to high sun temperatures resulting in vaporization, increased pressures and alteration of the gasoline's characteristics due to the loss of these vapors. Inside buildings, mains should preferably be overhead and located away from mechanical handling equipment which might come in contact with the pipe. Installation in tunnels is not desirable unless the line is enclosed in a vented guard pipe to prevent vapor leakage into the tunnel. When necessary to install inflammable liquid lines in trenches in the floor it is good practice to fill the entire trench with sand, although vapor detecting devices have been used on some occasions in trenches having removable covers, when sand back filling was omitted.

Proper installation of electrical equipment should not be overlooked in providing a safe gasoline handling system. The overhead unloading of gasoline from connections available in the top of tank cars is recommended, as illustrated in Fig. 8. There are many ways of erecting the unloading station, but all consist of a vertical pipe, swing joints to permit four-way movement of the drop pipe or flexible hose which is inserted in the tank car dome. The tank car, unloading pipe, and railroad tracks at the unloading siding must all be grounded to dissipate any static electricity that may be generated by the flow through the piping, conducted through the rails, or due to a number of other causes. Since gasoline is one of the inflammable liquids which have poor electrical conductivities, it can accumulate dangerous charges which if not drained away through a ground connection can cause a spark of sufficient intensity to ignite vapors in the surrounding atmosphere. Therefore, all motors, starters, pumps, fans, etc., in a pump room should also be effectively grounded as well as above ground storage tanks. Below ground tanks should also be grounded where buried in soil too dry to produce an effective natural ground. All motors, starters, fuses and switches in a confined space like pump houses, tank manheads or dispensing rooms should be of explosion-proof construction in accordance with the National Electrical Code recommendations for Class I, Group D, locations. All wiring should be installed in rigid steel conduit with fittings approved for use in explosive atmospheres. Adequate lighting should always be provided with vapor-tight fixtures well-guarded so that portable extension cords are unnecessary. When these must be used, they should be of special construction with plugs and lights suitable for hazardous vapor locations.

It is readily understandable from the foregoing discussion why emergency shut-off valves are necessary. Lubricated plug cocks with special lubricant for gasoline service are advocated in place of ordinary plug cocks. Certain types of packless valves are also used but when packed valves are employed the stuffing boxes should be on the low pressure side of the valve. Where gasoline distribution lines enter a main building, emergency shut-off valves should be installed on the outside of the building or inside near an exit and remotely located from any hazardous areas. Emergency electrical switches at convenient locations are recommended

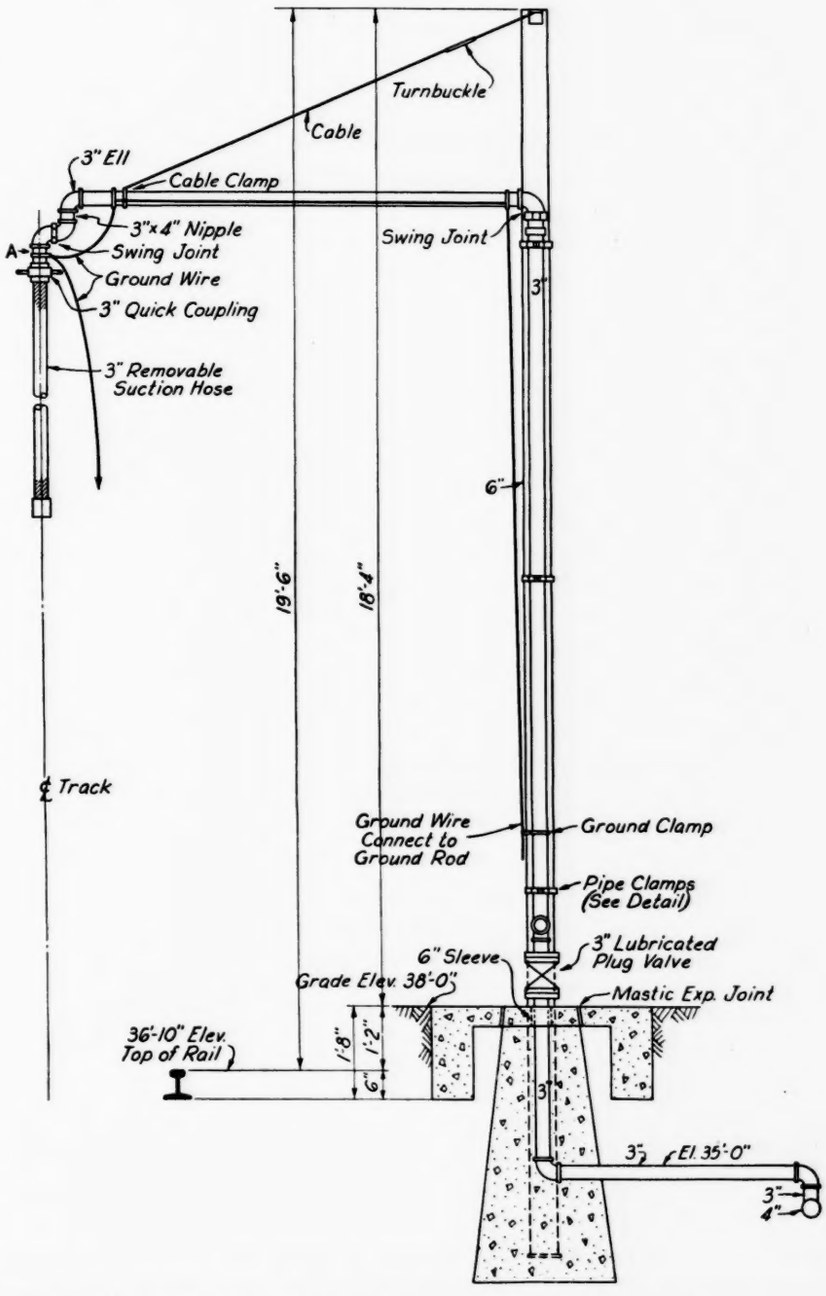


Fig. 8. Equipment for overhead unloading of gasoline from connections in top of tank cars.

to shut-off the delivery pumps, or master control valve in an hydraulic delivery system, so as to remove all pressure from the distribution system. This is extremely important in case of fire and possible rupture of the mains which, if under pressure, would discharge inflammable liquid and cause the fire to spread. On above ground tanks the discharge valve should be of the weighted lever type with flexible link which will automatically close when the link is melted. It cannot be repeated too often that a well-designed system must also be a safe system.

Underwriters' Standards

In the previous article on oil piping (See HEATING AND VENTILATING, September to December, 1944) the standards for fuel oil storage tanks as recommended by the National Board of Fire Underwriters was discussed in detail. A brief comparison of these requirements with those for gasoline or other "flammable liquids" is given below:—

(1) The minimum distance of above ground storage tanks to the line of adjoining property or nearest building is slightly less than for fuel oil tanks;

(2) The minimum distance between above ground tanks is the same for similar capacities;

(3) Underground tanks are constructed of the same thickness of shell as fuel oil tanks of the same capacity;

(4) Horizontal or vertical tanks not over 1100 gallons capacity are specified to have the same minimum shell thickness as for fuel oil tanks;

(5) Horizontal tanks over 1100 gallons capacity have the same specifications as for fuel oil and in addition should have dished, stayed, braced or reinforced heads for tank diameters over 6 feet. Tanks shall also be designed to withstand a venting pressure of at least 5 lb per sq in and shall be tested at a pressure of at least 8 lb per sq in for a period of at least 10 minutes without leakage or permanent deformation. Vents or emergency relief openings shall be provided for a maximum allowable internal pressure of 5 lbs per sq in. Tanks for higher pressures are beyond the scope of the Underwriters' specifications and should be designed in accordance with the A.S.M.E. Code for Unfired Pressure Vessels;

(6) Vertical tanks over 1100 gallons capacity shall have the same minimum shell, bottom and roof thickness as specified for fuel oil tanks. However, the formula for computing the thickness of shell plates has been modified to take into account the specific gravity of the liquid. A "short" formula for thickness is as follows:—

$$t = t_f \times s$$

where t = thickness of plate in inches for gasoline storage tanks,

t_f = thickness of plate in inches for fuel oil storage tanks as given in the previous article, and

s = specific gravity of gasoline (water=1)

Conclusion

We have discussed the several types of gasoline handling systems for manufacturing plants and airports. Small installations for garages and service stations are similar and have the same relative merits as the larger jobs. It is not our purpose to recommend or suggest in the scope of this article which system should be used as there are too many factors involved such as construction conditions at the site, power and water costs, maximum and minimum system demand, number of products to be handled, etc., which must be given consideration for each individual project. Each method of storage and handling has been tested by experience and is reliable; and in many cases their field of application overlaps so that it would be extremely unwise to think that any particular system is superior for all types of installations.

A point that should be emphasized is that close cooperation is needed between the designing, construction and maintenance groups to insure a balanced and economical installation. A system which is low in first cost is not economical if the operating and maintenance costs are excessive. For this reason, the designing engineer must be familiar with maintenance problems and, in so far as practicable, he must foresee those items which, through the natural course of operation, will require attention and arrange the installation so that repairs and replacements can be made economically.

Temperature, volatility and the composition of gasolines seriously influence the method of storage and distribution. Neglect in giving them full consideration may result in the otherwise perfect installation being a complete failure. It should therefore be a rule to know the characteristics of the liquid being handled and design the system in accordance with the best engineering practice to meet these requirements.

Ventilation for Vinyl Carbazole

A new dielectric, vinyl carbazole, is being used in the production of electrical equipment and has been found to produce dermatitis on workers engaged in manufacturing involving this material. A study made by Irving R. Tabershaw and John B. Skinner, both of the Massachusetts Division of Occupational Hygiene, recommend certain handling procedures.

Included in these precautions are the following: Tanks in which melting and impregnating are done should be placed within enclosures and a velocity of 200 fpm maintained through all openings; local exhaust hoods should be placed over doors of ovens where polymerization takes place. A face velocity of 200 fpm should be maintained.

New Developments in Washington

Amended General Refrigeration and Air Conditioning Order L-38 Awaited; Safeguards to Avert Coal Shortage

LORING F. OVERMAN

WITH the Big Push across the Rhine well started at the time this column is being written, the Washington news outlook is somewhat the same as it was last November. Capital news sources are again assuming that "anything might happen" attitude, with certain noticeable differences.

For one thing, no one talks in terms of V-E dates or what might happen, industrially speaking, on such a day. Too, last November's surpluses of basic materials have disappeared—particularly steel, and to a lesser extent, copper. To these may be added the stepped-up draft program and their reflected manpower shortages. The result is a general slowing down of the relaxation of any restrictions that may have been contemplated, and a tendency on the part of officials to keep mum regarding proposed changes, in the hope of avoiding disappointments that inevitably follow premature announcements.

Freon Order Delayed

Case in point is the Freon-12 order (M-28), scheduled for amendment early in March to make the refrigerant available to those on a lengthy list of users denied deliveries for more than a year. As late as March 26 this amendment had not yet been published, although WPB officials still opined it would be out in "a day or two".

The delayed appearance of the amendment does not indicate an unfavorable change in the Freon supply situation. Instead, it appears to reflect the reluctance of the military to approve the release to civilians of anything the Army or Navy might conceivably require in an emergency. Members of the General Refrigeration and Air Conditioning Advisory Committee, meeting March 14 in Washington, were told that inventories of Freon are now at approximately the level WPB wishes to maintain as a safety margin against unforeseen developments. Production of Freon since January 1 has been maintained at high levels and has met expectations, IAC members were told.

To those who await the release of Freon for comfort air conditioning systems, this should be favorable news, for it indicates that any marked reduction in military consumption — such as would doubtless follow an armistice in Europe — would make available almost immediately a surplus inventory of considerable size.

Order L-38 Change Imminent

An amended version of Order L-38, the general refrigeration and air conditioning order, was also expected early in April. It is likely that members of the Industry Advisory Committee will await the appearance of this order in its final form with great interest, for the committee session at which this was discussed was marked by sharp disagreements. WPB has proposed that the amended order embody the following points:

1. It is proposed that production restrictions of the order remain unchanged;

2. It is proposed that the order be modified to indicate that any increases in production of equipment for civilian use will be brought about under the spot authorization procedure (Priorities Regulation No. 25) rather than through modification of quotas in the order. In this connection, the committee expressed the belief that some spot authorizations have been granted to refrigeration producers without adequate screening, and recommended that WPB take steps to tighten up its review procedure. (The insistence of WPB to authorize civilian production under the spot authorization plan touches upon a delicate point in inter-industry relations. Spot authorization procedures allot materials on the basis of a plant's ability to produce civilian items without interfering with war work. Under this plan, the plant busiest with war contracts would be the last to get back into civilian production—a prospect not to the liking of many industries whose services and products are likely to be needed for the duration of the Pacific campaigns.)

3. It is proposed that provisions requiring that orders for refrigeration and air conditioning equipment be rated AA-5 before purchasers can place them and manufacturers accept them remain unchanged. It is further proposed that reference to the use of forms WPB-541 and WPB-547 by jobbers and dealers for building inventory be eliminated from the order. In some rare instances, WPB-547 applications for preference ratings on these forms will be honored to permit the building of inventories. For example, if a dealer's store burned down, destroying his inventory, WPB might grant rating on WPB-547 to permit him to build a small inventory for his operations. WPB-547 may still be used for ratings for repair parts inventory, exclusive of condensing units.

4. It is proposed to include in the order a provision to prevent the use of preference ratings assigned for authorized production schedules (CMP) to place orders for equipment—particularly condensing units—merely for redistribution where the person applying such a rating does not process the item purchased. This provision is designed to prevent the up-rating of purchase orders for certain types of refrigeration equipment through use of the CMP rating patterns that in the case of most manufacturers are higher than the ratings purchasers serve on them. Futhermore, it will tend to eliminate certain inequities that have existed as between dealers and jobbers, the latter being required to extend their customers' ratings while dealers have been permitted to place orders on manufacturers who in turn have placed orders for resale, using their CMP rating patterns.

5. It is proposed to re-emphasize that CMP-9A ratings (granted service and repair shops) may not be used to get parts to modify or convert any new or used refrigeration or air conditioning system from one type to another. For example, such ratings could not be used to obtain parts with which to convert an ice cream cabinet into a home freezing unit.

"Must" Programs Discussed

The probable negative effect of present war material "must" programs on civilian production was explained to IAC members by William M. Haile, director of WPB's General Industrial Equipment Division. Both materials and manpower shortages have been brought about by these must programs, Mr. Haile said, pointing out that both of these factors will affect production of civilian refrigeration and air conditioning items in certain areas. In addition, he said, the manpower shortage

will affect the operation of dealers, jobbers, servicemen and repair shops, all of which are a part of the industry.

The War Manpower Commission has officially notified WPB's Office of Manpower Requirements that production of industrial and commercial refrigeration and air conditioning machinery and equipment is included in Group 15, Production of Industrial and Agricultural Equipment, on WMC's List of Essential Activities. This means that certain workers engaged in the production of refrigeration equipment are eligible for deferments, depending upon local conditions and availability of replacement workers in specific areas.

Motors Outlook Unchanged

There has been little change in the fractional horsepower motor supply situation to affect the refrigeration industry, committee members were told by Robert Hanna, of the Fractional Horsepower Motor Section of GIEQ. Effective use of facilities for production of motors has been reduced, Mr. Hanna said, as a result of manpower shortages, and it is expected that within the near future some loss of production may result. Other factors which have tended to reduce the effective use of motor production facilities have been lack of fuel, transportation embargoes, and reduced supplies of certain copper products.

Controls Manufacturers Meet

That post-war thinking still goes on in Washington, despite the reluctance of most officials to discuss it, is indicated by the subjects discussed at a recent meeting of the Electrical Control Manufacturers Industry Advisory Committee. Meeting with officials of the Office of Price Administration, the discussions centered around the possible need for ceiling price adjustments after the war.

A point of interest to heating and ventilating engineers brought out at the meeting was that the controls industry expects to be slow in getting back into civilian production, since its present production consists mainly of electrical controls used in Army tanks and airplanes.

Peacetime production of electrical controls is valued at $50,000,000 to $60,000,000, with wartime production about doubled.

The committee elected the following officers: chairman, W. L. Huff, vice-president, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.; vice-chairman, Malcolm E. Henning, vice-president, Penn Electric Switch Co., Goshen, Ind.; and secretary-treasurer, V. R. Tate, vice-president, Perfex Company, Milwaukee, Wis.

Commercial Stokers Recommended

How even the manufacturers' conceptions of needs and possibilities have changed since last Fall were indicated at the March meeting of the Stoker Manufacturers' Industry Advisory Committee. During last Fall's optimistic pre-victory period, the committee urged that liberal quotas of materials be made available for the production of Class B Stokers—those of smaller sizes. At its recent meeting, the committee recommended the production of more large size (Class A) stokers, because the larger sizes conserve more coal and utilize the limited steel available more effectively.

Stokers installed in 1944, about 40,000 in number, saved approximately 1,000,000 tons of coal, according to recently completed studies, WPB officials said. The importance of conserving coal was emphasized in a review of the coal supply situation. Bituminous coal production in 1945 will be about 50,000,000 tons short of estimated demand, and anthracite coal will be about 4,500,000 tons less than 1944 production.

The amount of steel available for stoker production in the second quarter of 1945 is considerably less than that allotted in the first quarter, the committee was informed. Committee members reported that the demand for stoker equipment is heavy and that the industry will tend to produce large size stokers with the limited amounts of steel available.

Coal Shortage Safeguards

Faced with a constantly dropping coal stockpile and the announced intention of John L. Lewis' union to strike, the Solid Fuels Administration has outlined several important steps intended to partially solve the problem. First is the establishment of a solid fuels heating year, starting April 1, with household consumers limited to 80% of their normal requirements. All consumers east of the Mississippi River, as well as in some other designated areas, are required to file consumer-declarations with dealers. The declarations will show the amount of solid fuel normally required at the building in which it is to be used, the kinds and sizes ordinarily burned, and the number of rooms to be heated. Other areas affected are Minnesota, North and South Dakota, Iowa, Louisiana and the city and county of St. Louis, Mo.

The new retail control places the 80% over-all restriction on deliveries for use in a house, apartment, hotel or other dwelling; in schools, churches and meeting houses, court houses, prisons, police or fire stations, libraries, museums, banks, offices or office buildings, stores and retail establishments of all kinds (except commercial bakeries or laundries), passenger terminals and depots of all kinds, warehouses, garages, restaurants, taverns or bars, gymnasiums, auditoriums, theaters, clubs or lodge rooms, places of amusement, dancing studios, zoos, stables, kennels and in any building or plant not specifically mentioned in which solid fuel is used only for space heating, the domestic heating of water or domestic cooking.

A new priority list, by classes, is as follows:

Class 1: All plants only to the extent necessary to prevent irreparable damage to equipment that may result if a coal shortage exists, subject to special certification by the district managers of WPB. (Coke plants, steel plants and glass plants may be considered as examples.)

Class 2: (a) Bunker fuel (ship use) if less than seven days' stockpile, based on long run average of requirements, is available;

(b) Railroads, if less than seven days' stockpile, including coal on ground, is available;

(c) Public utilities, including gas, electric light and power, street railways, communications, water-works and sewage disposal plants, if less than 10 days' stockpile is available.

Class 3: Minimum requirements for hospitals and similar institutions, central steam plants, domestic households, military cantonments, navy stations, and other living quarters, hotels and apartments during the heating season.

Class 4: Critical plants and services that receive from WPB certification of eligibility for coal deliveries in this class, which will include plants and products specified in the current National Production Urgency List, and plants equally essential in war production.

Class 5: (a) The manufacture of any product, or the conduct of any business or activity not previously covered herein, rated AA1 for maintenance, repair and operating supplies as set forth in Program Determination No. 500-B and reflected in CMP Regulations Nos. 5 and 5A, and Orders P-56, P-68, P-98-b, and P-142.

(b) Minimum requirements after all possible curtailment for office buildings, restaurants, passenger stations; manufacturing plants using coal only for space heating.

Class 6: The manufacture of any product, or the conduct of any business or activity not previously covered herein, rated AA2 for maintenance, repair and operating supplies as set forth in CMP Regulations Nos. 5 and 5A, except schools and other public buildings not directly required in the war effort.

Class 7: The manufacture of any product, or the conduct of any business or activity not otherwise covered in Classes 1 through 6.

Degree-Days for February, 1945

HEATING AND VENTILATING'S 18TH YEAR OF PUBLICATION OF MONTHLY DEGREE-DAY DATA

CITY	FEBRUARY			CUMULATIVE, SEPTEMBER 1 TO FEBRUARY 28			HEATING SEASON[1]
	1945	1944	NORMAL	1945	1944	NORMAL	NORMAL
Abilene, Texas	455	410	510	2123	2058	1761	2061
Albany, New York	1124	1203	1142	5332	5200	4868	6580
Albuquerque, New Mexico	621	727	692	3265	3750	3443	4298
Alpena, Michigan	1230	1213	1278	5639	5395	5660	8299*
Anaconda, Montana	1049	1190	1164	5376	5399	5656	8357**
Asheville, North Carolina	638	624	756	3097	3255	3276	4232
Atlanta, Georgia	473	446	557	2470	2329	2370	2890
Atlantic City, New Jersey	827	840	904	3699	3538	3631	5176
Augusta, Georgia	349	344	423	1936	1850	1864	2161
Baker, Oregon	867	1006	991	4647	4761	5024	7163
Baltimore, Maryland	735	783	843	3531	3340	3462	4533
Billings, Montana	1072	1147	1120	4852	4543	5254	7119
Binghamton, New York	1080	1126	1182	5191	5093	4965	6808
Birmingham, Alabama	442	406	521	2285	2396	2023	2352
Bismarck, North Dakota	1352	1519	1548	6223	5695	6869	9192
Block Island, Rhode Island	929	979	983	4055	3956	3767	5788
Boise, Idaho	766	898	848	4038	4296	4230	5552
Boston, Massachusetts	965	1030	1042	4417	4301	4322	6045
Bozeman, Montana	1066	1193	1208	5362	5497	5897	8521**
Buffalo, New York	1088	1156	1156	5111	4969	4768	6822
Burlington, Vermont	1250	1402	1294	5947	5857	5496	7514
Butte, Montana	1079	1256	1143	5646	5873	5635	8272
Cairo, Illinois	701	622	762	3274	3131	3169	3909
Canton, New York	1261	1364	1328	6204	5900	5842	8020
Charles City, Iowa	1260	1199	1273	5631	5388	5728	7588
Charleston, South Carolina	314	286	372	1672	1563	1491	1769
Charlotte, North Carolina	524	522	588	2640	2478	2533	3120
Chattanooga, Tennessee	602	517	602	2936	2849	2559	3118
Cheyenne, Wyoming	1042	1102	1075	4936	4986	5179	7466
Chicago, Illinois	980	1044	1083	4713	4641	4276	5957
Cincinnati, Ohio	858	786	862	4115	3758	3675	4684
Cleveland, Ohio	989	983	1075	4636	4323	4441	6155
Columbia, Missouri	863	835	897	3995	3939	3903	4922
Columbia, South Carolina	394	377	498	2093	1997	2000	2364
Columbus, Ohio	903	864	980	4346	4026	4113	5398
Concord, New Hampshire	1173	1285	1240	5598	5541	5321	7353
Concordia, Kansas	876	897	970	3908	4053	4173	5315
Dallas, Texas	419	382	493	1961	2014	1980	2256
Davenport, Iowa	1033	1047	1140	4791	4538	4825	6289
Dayton, Ohio	976	923	980	4623	4323	4043	5264
Denver, Colorado	847	921	918	3897	3976	4273	5874
Des Moines, Iowa	1052	1048	1173	4805	4665	4935	6384
Detroit, Michigan	1046	1053	1134	4916	4702	4718	6490
Devils Lake, North Dakota	1478	1652	1551	6747	6499	7371	9970
Dodge City, Kansas	865	842	890	3829	4077	3958	5035
Dubuque, Iowa	1124	1109	1218	5167	4897	5194	6790
Duluth, Minnesota	1407	1468	1464	6439	6376	6680	9443
Eastport, Maine	1127	1286	1232	5271	5453	5502	8520**
Elkins, West Virginia	884	852	991	4605	4392	4256	5697
El Paso, Texas	379	452	434	2063	2351	2101	2428
Ely, Nevada	1011	1217	—	5283	5428	—	—
Erie, Pennsylvania	1022	1051	1098	4552	4527	4434	6273
Escanaba, Michigan	1301	1268	1340	5901	5653	6028	8771*
Evansville, Indiana	811	750	854	3843	3688	3348	4244
Fort Smith, Arkansas	601	512	630	2636	2614	2657	3147
Fort Wayne, Indiana	1034	1047	1098	5068	4817	4503	5925
Fort Worth, Texas	438	390	498	1964	1971	1904	2148
Fresno, California	396	475	389	2032	2008	1883	2334
Galveston, Texas	175	136	255	917	1028	938	1016
Grand Junction, Colorado	734	871	863	3693	4034	4374	5548
Grand Rapids, Michigan	1039	1057	1204	4859	4716	4863	6535
Green Bay, Wisconsin	1292	1217	1358	5695	5453	5778	7825
Greensboro, North Carolina	645	673	678	3221	3163	2845	3529
Greenville, South Carolina	517	510	661	2624	2496	2739	3380
Harrisburg, Pennsylvania	916	930	1008	4280	4107	4077	5375
Hartford, Connecticut	1042	1063	1100	4876	4638	4416	6036
Hatteras, North Carolina	522	462	535	2256	2123	1851	2571
Havre, Montana	1275	1231	1450	5918	5096	6388	8700
Helena, Montana	1074	1213	1178	5594	5536	5611	7898
Houston, Texas	195	164	277	1088	1145	1092	1157
Huron, South Dakota	1209	1445	1340	5597	5605	6075	8004
Indianapolis, Indiana	884	877	969	4268	4048	4099	5298
Jackson, Miss.	341	—	—	1859	—	—	—
Kansas City, Missouri	840	847	946	3767	3855	3953	4956
Kewanee, Illinois	997	1054	1106	4637	4813	4640	6139
Knoxville, Tennessee	596	548	666	3053	2928	2964	3670
La Crosse, Wisconsin	1210	1325	1265	5398	5575	5578	7322
Lander, Wyoming	1148	1410	1155	6181	6115	5666	7947

[1]Figures in this column are normal totals for a complete heating season, September to June, incl.

Figures in this table, with nine exceptions, based on local weather bureau reports. Exceptions are Utica, Lewiston, Kewanee, Sioux City, and Jackson, figures for which are furnished through the courtesy of Coke Sales Department, Central New York Power Corp., Utica, N. Y.; Norman E. Ross, Bursar, Bates College, Lewiston, Me.; J. M. Hartman, Engineering Department, Kewanee Boiler Corp., Kewanee, Ill., Alfred R. Wagstaff, Engineer, Sioux City Foundry and Boiler Co., Sioux City, Iowa, and H. M. Ludlow, Box 1368, Jackson, Miss., respectively; Anaconda, Bozeman, Butte and Livingston, Mont., through the courtesy of the Montana Power Company.

(a) Data not available.

[Table concluded on page 102]

Degree-Days for February, 1945 (Concluded)

HEATING AND VENTILATING'S 18TH YEAR OF PUBLICATION OF MONTHLY DEGREE-DAY DATA

CITY	FEBRUARY			CUMULATIVE, SEPTEMBER 1 TO FEBRUARY 28			HEATING SEASON[1]
	1945	1944	NORMAL	1945	1944	NORMAL	NORMAL
Lansing, Michigan	1109	1152	1201	5349	5187	5202	7048
Lewiston, Maine	1231	1330	1243	5690	5891	5532	7707
Lincoln, Nebraska	944	1020	1131	4293	4351	4643	5999
Little Rock, Arkansas	603	472	582	2651	2526	2380	2811
Livingston, Montana	1010	1113	1067	4953	4703	5018	7205
Los Angeles, California	244	329	266	888	946	1016	1504
Louisville, Kentucky	775	687	801	3650	3352	3327	4180
Lynchburg, Virginia	700	681	730	3541	3033	3143	3980
Macon, Georgia	338	345	462	1956	1969	1908	2201
Madison, Wisconsin	1197	1177	1299	5482	5254	5557	7429
Marquette, Michigan	1242	1266	1361	5737	5591	5915	8693*
Memphis, Tennessee	584	463	599	2770	2616	2470	2950
Meridian, Mississippi	382	320	456	2000	1993	1891	2160
Milwaukee, Wisconsin	1126	1145	1201	5226	5160	5185	7245
Minneapolis, Minnesota	1326	1290	1400	5748	5553	5950	7850
Modena, Utah	849	1053	905	4487	4753	4764	6562
Montgomery, Alabama	308	280	392	1663	1732	1676	1884
Nantucket, Massachusetts	925	982	974	3971	3949	3912	5957
Nashville, Tennessee	649	537	675	3148	2922	2850	3507
New Haven, Connecticut	994	1042	1011	4549	4423	4230	5895
New Orleans, Louisiana	158	115	230	933	1092	965	1024
New York, New York	857	936	960	3984	3890	3869	5347
†Nome, Alaska	1466	1855	1990	6458	6760	7226	14580**
Norfolk, Virginia	586	628	650	2764	2641	2583	3350
North Head, Washington	572	604	725	2736	2775	2510	5452**
North Platte, Nebraska	937	1114	1020	4439	4577	4806	6366
Oakland, California	381	447	403	1961	1929	2029	3143**
Oklahoma City, Oklahoma	673	592	742	2803	2832	2986	3613
Omaha, Nebraska	1016	1068	1126	4606	4619	4765	6131
Oswego, New York	1072	1158	1162	5132	5033	4933	7088
Parkersburg, West Virginia	841	786	879	4111	3861	3701	4775
Peoria, Illinois	991	1031	1067	4785	4656	4673	6109
Philadelphia, Pennsylvania	804	853	893	3780	3583	3629	4855
Phoenix, Arizona	243	355	263	1222	1248	1253	1405
Pittsburgh, Pennsylvania	867	894	944	4200	4048	3947	5235
Pocatello, Idaho	891	1094	986	4900	5080	4853	6655
Portland, Maine	1201	1273	1162	5534	5524	5088	7218
Portland, Oregon	534	606	644	2811	2852	3174	4469
Providence, Rhode Island	944	1004	1070	4282	4213	4316	6015
Pueblo, Colorado	856	899	916	4118	4352	4140	5514
Raleigh, North Carolina	563	583	630	2830	2715	2605	3234
Rapid City, South Dakota	1132	1270	1119	5042	4966	5140	7118
Reading, Pennsylvania	880	916	980	4168	3954	4082	5389
Red Bluff, California	377	—	—	1937	—	—	—
Reno, Nevada	(a)	868	823	(a)	4216	4149	5892
Richmond, Virginia	648	687	695	3155	3039	2906	3695
Rochester, New York	1113	1192	1159	5300	5086	4825	6732
Roseburg, Oregon	527	615	605	2755	2912	3090	4428
Roswell, New Mexico	487	563	580	2643	2950	2876	3484
Sacramento, California	360	462	426	1959	1957	2036	2653
St. Joseph, Missouri	880	907	974	4031	4091	4121	5161
St. Louis, Missouri	827	778	854	3799	3545	3652	4585
Salt Lake City, Utah	778	941	885	3749	4516	4144	5555
San Antonio, Texas	278	252	274	1437	1468	1128	1202
San Diego, California	232	303	280	929	929	1099	1645
Sandusky, Ohio	986	982	1061	4653	4352	4384	6208
San Francisco, California	302	386	356	1646	1559	1770	3264**
Sault Ste. Marie, Michigan	1351	1397	1487	6416	6121	6315	9285**
Savannah, Georgia	240	222	316	1395	1313	1323	1490
Scranton, Pennsylvania	1022	1055	1106	4917	4675	4552	6129
Seattle, Washington	568	614	647	2758	2852	3297	4934**
Sheridan, Wyoming	1149	1259	1160	5156	5170	5789	8008
Shreveport, Louisiana	364	309	412	1911	1908	1736	1938
Sioux City, Iowa	1114	1204	1260	4073	5096	5278	6898
Spokane, Washington	837	942	952	4300	4514	4707	6355
Springfield, Illinois	884	899	1008	4645	4095	4191	5373
Springfield, Missouri	825	748	876	3714	3669	3523	4428
Syracuse, New York	1083	1176	1212	5283	5173	4980	6893
Tacoma, Washington	604	655	675	3059	3182	3438	5181**
Terre Haute, Indiana	850	859	966	4132	3953	3876	4872
Toledo, Ohio	1051	1069	1075	5104	4792	4467	6077
Topeka, Kansas	843	829	935	3742	3807	3953	4969
Trenton, New Jersey	865	906	941	4102	3949	3715	4933
Utica, New York	1143	1260	1181	5635	5513	4966	6796
Valentine, Nebraska	1090	1268	1130	5149	5109	5225	7039
Walla Walla, Washington	646	770	778	3441	3814	3676	4808
Washington, D. C.	743	778	848	3582	3411	3559	4626
Wichita, Kansas	830	762	896	3521	3551	3773	4673
Williston, North Dakota	1308	1419	1495	6195	5717	6958	9323
Winnemucca, Nevada	802	964	905	4444	4539	4644	6427**
Yakima, Washington	709	820	846	3822	4116	4433	5599

†Nome data are for January.
(a) Data not available.

*Includes August.
**Includes July and August.

[1]Figures in this column are normal totals for a complete heating season, September to June, incl.

NEWS OF THE MONTH

ASHVE to Study Industrial Ventilation

DETROIT—Thirty engineers, industrial hygienists and others interested in industrial ventilation met here March 13 at a meeting called by the ASHVE to determine how that organization might assist in providing more adequate technical information on this general subject. Professor G. L. Tuve, of Cleveland, chairman of the Society's committee of research, presided at the meeting.

In opening the meeting, Professor Tuve stated that the conference was, in a sense, a preliminary step in the formation of a committee to bring about closer cooperation between the Society and industrial hygiene engineers, with the field to be covered that of industrial ventilation where conditions injurious to health are involved.

Meeting to consider industrial ventilation

There was agreement that the problem under discussion becomes one where the following are concerned: (1) Where desirable toxic conditions exist; (2) by what mechanism are they generated; and (3) how can they be removed or diluted until they are no longer harmful?

W. N. Witheridge, Detroit, suggested that health is only one of the factors to be considered; safety and fire hazards, damage to equipment, nuisance and annoyance factors all may be part of the problem of industrial ventilation. He suggested that the scope of the Society's work, in conjunction with other groups, should be the control of air contaminants within industry, not limited to those strictly considered as health hazards.

Cyril Tasker, director of the ASHVE Research Laboratory, reported progress made at the Laboratory on analysis of state and municipal codes, but pointed out that this study did not include codes covering toxic substances.

Dr. Clarence Selby, Detroit, stated that in present-day practice, it is the industrial hygiene engineer who finds the conditions which are harmful to health and the ventilating engineer who tries to cure them. The medical profession, however, has a definite part in this picture since they find those conditions in the employee which result from uncontrolled occupational exposures. Any attack on the problem should, therefore, be a coordinated one by all three groups.

L. L. Lewis, Syracuse, suggested that there were four basic questions: (1) What is contamination? (2) How do you measure it? (3) How do you fulfill the conditions of minimum contamination? (4) How do you check statistical data and make an analysis of the results obtained by remedial practices?

Professor C. H. Pesterfield, Lansing, Mich., said that at present there were several groups working independently and uncorrelated in this general field. He said that research work in industrial exhaust ventilation should be done by ventilation engineers. General ventilation, he continued, is not recommended in the field of industrial exhaust ventilation as a cure for many of the ills encountered. Dilution is only accepted as a last resort.

The majority of those present agreed that the ASHVE should not become involved in setting standards for permissible concentrations of air contaminants but should leave this to the medical profession and to industrial hygiene engineers. The ASHVE should set about to determine mechanical means or mechanical standards whereby industry can achieve the goals set by the groups that have established permissible concentrations.

The meeting approved the motion "That a committee be appointed by the chairman of the committee on research, to contact other organizations interested in the field of industrial ventilation in order to ascertain (a) what technical information is now available, and (b) what additional information should be made available through research, on engineering procedures for the control of industrial atmospheric conditions by means of ventilation."

Major A. D. Brandt, Chicago, accepted the chairmanship of the committee. Other members appointed are W. L. Fleisher, New York; Professor Pesterfield; Mr. Witheridge, and W. C. L. Hemeon, Pittsburgh. This committee will work with the Research Laboratory in collecting and correlating the information of interest to this study.

Walker V. P. of Detroit Edison

DETROIT—James Herbert Walker was elected vice-president of The Detroit Edison Company at a meeting of the board of directors March 20. He was employed by The Detroit Edison Company in 1912, following his graduation from the University of Michigan with a degree in mechanical engineering.

James Herbert Walker

For many years Mr. Walker has been superintendent of the company's central heating department which supplies steam service to the principal buildings in downtown Detroit. As assistant to the general manager Mr. Walker served in organization planning matters, and as a consultant on various commercial and economic problems affecting special industrial service. He has a wide experience in company affairs.

Mr. Walker is an honorary member and a past president of the National District Heating Association, author of a number of papers on heating and ventilating, and co-author of a text book on this subject. He and Sabin Crocker of Detroit Edison have published a handbook on piping. For years he has taken an active part in the work of several scientific, mechanical engineering, heating and ventilating societies.

Fan Manufacturers Elect Officers

ST. LOUIS—The Propeller Fan Manufacturers Association held their annual meeting on February 21, 1945, at the Hotel Statler in St. Louis, Mo.

The following officers were elected to serve during 1945: H. M. Guilbert, B. F. Sturtevant Company, president; E. C. Englert, Hartzell Propeller Fan Co., vice-president; V. C. Shetler, 2-255 General Motors Bldg., Detroit 2, Mich., secretary-treasurer.

Fuel Savings Result from Efficiency Drive

WASHINGTON—Fuel savings ranging from 3 to 35% in industrial plants, office buildings, schools and colleges, apartment houses, Government buildings and other commercial consumers were reported at a recent meeting of the National Fuel Efficiency Council and Bureau of Mines Officials here.

Nearly 10,000 plants throughout the country have been visited and surveyed by volunteer engineers working in the National Fuel Efficiency Program which is sponsored by private industry and the Bureau of Mines, the council was informed. Pledges of cooperation have been signed by operators of these plants, and a "waste chaser" has been appointed in each plant to put into use the technical information provided by the Bureau of Mines and the volunteer engineers.

Many manufacturers have cooperated further by contributing their paid advertising space in business papers for messages concerning the need for the program, and others have lent the services of their engineering staffs for the preparation of "quiz sheets" and other informative material on methods for preventing fuel waste.

To offset at least a part of the 1945 deficit in fuel production is the objective of the National Fuel Efficiency Program. At the outset of the campaign, a goal was established to save 29 million tons of coal each year and proportionate amounts of oil and natural gas through more efficient utilization by industrial and commercial consumers.

Progress toward this goal was disclosed at the meeting of the council, which is composed of some of the Nation's leading fuel and combustion engineers. Members were told that substantial fuel economies have been reported by individual plants adopting modern combustion practices at the recommendation of the program's regional engineers, but that no over-all estimate of savings can yet be made. The signing of a pledge of cooperation alone tends to encourage fuel savings, staff members pointed out.

Indicative of the wide range of fuel consumers cooperating, a distribution breakdown of 1,300 pledges signed in seven areas—Albany and Buffalo, N. Y., Cincinnati and Springfield, Ohio, and Peoria and Elgin-Aurora, Ill.—shows that schools and colleges represent 19.6%; apartments, 4.2%; hotels, 2.5%; banks, stores, offices, and theaters, 13.9%; laundries and dry cleaners, 1.7%; telephone exchanges, post offices, and libraries, 4.7%; Y.M.C.A.'s, clubs, hospitals, churches, and institutions, 8.7%; plants, power plants, and factories, 35.8%, and installations not identified, 8.9%.

Public Buildings Administration, Federal Public Housing Authority, and other Federal agencies also are cooperating and are obtaining results, a report submitted at the meeting disclosed. Representative savings this year over last in Washington, D. C., office buildings, compiled on a degree-day basis, showed 25% for the Public Buildings and Administration's ABC group of buildings, 20% of the Hydrographic office, 30% for Navy, 33% for Munitions, and 16% for Temporary 8.

Still expanding their field organization, the directors of the National Fuel Efficiency Program now have appointed 181 area coordinators throughout the country with supervision over 5,000 regional engineers, all volunteers from industry. Coordinators, in turn, have appointed 726 persons to their advisory committees. Thirty-four "quiz sheets", providing fuel-efficiency information for different types of installations, have been printed, two more are being printed, and 12 others have been prepared.

In a discussion following the reports, council members suggested wider publicity to acquaint plant managers and owners with the purposes of the program before the regional engineer calls and the employment of more paid district engineers in the field.

Dr. R. R. Sayers, Director of the Bureau of Mines, opened the meeting by thanking the council members for their unselfish support in a voluntary program during a period of crisis which is growing more acute.

Members of the Council are Thos. C. Cheasley, chairman, fuel engineer for the Sinclair Coal Company, Kansas City, Mo.; O. F. Campbell, combustion engineer, Sinclair Refining Company, East Chicago, Ind.; W. G. Christy, smoke abatement engineer, Hudson County, N. J., Department of Smoke Regulation; C. F. Hardy, manager, fuel engineering division, Appalachian Coals, Inc., Cincinnati, Ohio; H. K. Kugel, smoke regulation engineer, District of Columbia; L. S. Reagan, vice-president, Webster Engineering Company, Tulsa, Okla.; C. A. Reed, director of engineering department, National Coal Association, Washington, D. C.; R. C. Johnson, vice-president in charge of research, Anthracite Industries, Inc., Philadelphia, Pa.; R. A. Sherman, supervisor, fuels division, Battelle Memorial Institute, Columbus, Ohio; A. W. Thorson, manager, power plant division, American Engineering Company, Philadelphia, Pa.; J. E. Tobey, managing director, Fairmont Coal Bureau, New York, N. Y.; and J. F. Barkley, ex-officio council member, Bureau of Mines, Washington, D. C.

Yantis Addresses ASRE

HARTFORD, CONN.—Roy C. Yantis, Wolverine Tube Co., Detroit, presented an illustrated slide lecture on "The Manufacture and Fabrication of Copper Tubing" before the third meeting of the newly formed Connecticut Valley section of the American Society of Refrigerating Engineers here March 15.

Roger F. Gleason, of the New Haven Branch of the F.B.I., spoke on the experiences and methods of F.B.I. procedure. The meeting was presided over by Arthur W. Towson, chairman of the section, and from Worthington Pump & Machinery Corp., Holyoke. Speakers were introduced by Vice-Chairman Robert H. Tull, Westinghouse Electric & Mfg. Co., Springfield.

A technical committee was appointed as follows: Chairman, Fred G. Riedel, Worthington Pump & Machinery Co., Holyoke; H. P. Peterson, Bush Manufacturing Co., Hartford; G. S. McCloy, Westinghouse Electric & Mfg. Co., Springfield. A membership committee has been organized to consider new members as follows: Raymond S. F. Graham, Graham Refrigeration Products Co., Springfield; R. W. Hastings, Westinghouse Electric & Mfg. Co., Springfield; and Donald H. McCuaigh, Worthington Pump & Machinery Co., Holyoke. The publicity committee has a new member—Harold M. Fifield, Worthington Pump & Machinery Co., Holyoke.

To Study Heat Flow

BOSTON—Dr. Harry Pollard, Dorchester, Mass., a member of the Applied Mathematics Group at Columbia University, has been awarded a Frank B. Jewett fellowship for research in physical science. Dr. Pollard plans to investigate problems of heat flow. He was graduated from Harvard in 1939, received his Ph.D. in 1942 and taught mathematics at Harvard. He served a term as assistant professor at Kenyon College. The award carries a stipend of $3,000 and allows for a year of uninterrupted work.

An Omission

In the February issue, there is an article describing the heating and boiler plant facilities at the Cushing General Hospital. Through an oversight the name of the Ric-wiL Company was omitted as one of the suppliers of material for the hospital. The Ric-wiL Company, through its district representative, the J. F. Tuttle Company, Boston, Mass., furnished well over a mile of conduit for underground steam line.

A. C. Requirements of Movie Industry Outlined

LOS ANGELES—Present problems and future requirements of motion picture studios in air conditioning to neutralize the tremendous heat output of light banks on technicolor stages were discussed in a talk presented at the March 14 meeting of the Southern California chapter of the ASHVE by John L. Blake, chief engineer, air conditioning division, Metro-Goldwyn-Mayer Studio.

Addressing some 50 heating and air conditioning engineers, Mr. Blake outlined some of the problems the studios encounter with respect to temperature and air control and air distribution on stages, and humidity regulation and air filtering in film drying laboratories.

The speaker predicted that after the war there will be a tremendous demand for air conditioning by the major film studios in virtually every phase of air control, cooling and distribution. Many of the studios, he pointed out, have had to mark time insofar as expanding their existing air conditioning systems is concerned because the war emergency has made equipment unavailable. These studios will, he predicted, want to proceed with modernization programs of air control systems on sound stages and in laboratories as soon as the war condition permits.

"The advent of technicolor films," Mr. Blake explained, "has created so many additional problems of air distribution, exhaust and refrigeration that this development alone will make a demand on the air conditioning industry for a huge volume of film studio work after the war's end."

He pointed out, for instance, that MGM sound stages built seven or eight years ago were designed for a load of 6000 amp. and an occupancy of 300 people. For technicolor work the cooling system was designed for 800 amp. and an occupancy of 300 to 400 persons.

"Showing how the rapid advances made in technicolor have altered conditions," Mr. Blake said, "a recent technicolor picture at MGM required a stage load of 13,000 amp. and there were 4,000 people involved in the action at times."

Film industry engineers, Mr. Blake disclosed, are considering the possibility of designing a stage with a load up to 30,000 amp.

Mr. Blake explained that a certain amount of haze and smoke is inevitable on a stage and with the big loads of the type mentioned it is impossible to remove the haze and smoke with present equipment. The problem which the studios are preparing to present to the air conditioning industry for solution after the war, he said, is how to obtain air supply, exhaust and temperature control in balanced ratios to provide sufficient cooling for a stage carrying the amount of load and occupancy that will be used after the war.

Neutralization of the heat radiated by the batteries of lights required on a large stage is a problem, Mr. Blake said. At present, he said, the practice is to use vertical air dischargers in the form of some 50 supply vents mounted above the open-top stage. This system, according to Mr. Blake, exposes stage hands and technicians to considerable discomfort when, one moment, they are occupied beneath a supply vent in temperature of 50F, and shortly thereafter find themselves working in the 118F temperature beneath a bank of lights.

"Distribution of air on the stages is one of our industry's primary problems," Mr. Blake said. "It has been suggested that the vents be placed in the side-wall of the stage, or mounted in the floor. There are several reasons why this is not practical. On most stages, some time or other, false walls are erected in front of the permanent wall which would completely obstruct air vents mounted in the side wall. Putting the inlets in the floor is not feasible either, because stage settings often call for carpets, linoleums or other floor coverings."

Sound stage air exhaust systems are open to considerable improvement, in the opinion of Mr. Blake. He cited instances in which the script called for the introduction of dense clouds of smoke onto the stage for one scene, with the director demanding the smoke be cleared out immediately so that the set could be used for a subsequent scene.

Mr. Blake cited another problem of air control awaiting solution. Sometimes, he declared, a set covers the entire stage and all air supply vents must be opened to provide sufficient refrigeration. At other times a set will occupy only one section of the stage, but it will still be necessary to use all the vents, because there is no method at present whereby cooling can be limited to one section and kept out of another.

Mr. Blake suggested that future designs for sound stage cooling systems might possibly incorporate the zoning of supply air, which would make it feasible to shoot a double amount of cool air into one section of the stage and a reduced amount, measured to the requirements of another section.

Mr. Blake also accented various air control and humidity problems involved in the operation of a film drying laboratory. He prefaced his discussion of this phase of his talk by narrating the history of film drying technique from the early days of the industry when all film "shot" in Southern California was shipped to New Jersey for development.

"In the early days of the picture industry, he said, "the web of wet film was draped over a drum which was turned by hand. No forced draft air was applied. On days of high humidity the wheel could be turned all day by hand and the film would be no dryer at night."

Mr. Blake related how forced draft air was finally used by the installation of a fan outside the drying room with a duct running to a window through which air was blown into the room. Eventually, he explained, the idea was adopted of installing the fan inside the drying room to blow the moist air out, which, he said, represented an important step forward in film drying.

Notwithstanding the improvements that have been made in the technique of film drying, Mr. Blake declared that filtering of air is still a problem in the film laboratory. Modern air conditioning systems, he asserted, include good filters for washing the air inside the drying room, or air which enters through the air conditioning system itself. There is present, however, he explained, the problem of secondary dust—dust and impurities which are carried into the drying room on the clothes and shoes of employees.

Mr. Blake said he sees the need for improvement in film laboratory drying rooms after the war. He accented the definite need for some method of conquering the secondary dust problem. This might be accomplished, he suggested, by installing a lock system of doors—double doors—at the entrance to the laboratory to prevent impurities from being carried into the room when the outer door is opened.

Mr. Blake discussed another phase of air control which is used solely by the film industry. Present wind machines employed for creating artificial wind storms or gales by means of airplane propellers fall short of modern needs, Mr. Blake explained.

He cited the need by the studios of a wind machine capable of creating a 30-mile gale at a point 150 feet from the source of the air, and propelling the air stream with less "spread". Tests made at MGM, he said, disclosed that an airplane propeller can produce an air volume of 750 feet per minute at a distance of 140 feet from the machine. An anemometric test to determine the velocity, force and direction of the wind revealed that, by turning the propeller downward, an air speed of 1500 feet per minute could be obtained.

That speed, Mr. Blake said in conclusion, is still far short of the 30-mile gale demanded by the studio.

New Smoke Rules Proposed

LOS ANGELES—Drafting of a new county ordinance to make approval of combustion chamber of smokestack designs mandatory before a building permit is issued in unincorporated areas of Los Angeles County, was urged recently by County Health Officer H. O. Swartout.

Mr. Swartout recommended the ordinance after responsibility for solving the smoke and fumes problem in the county had been returned to this department when the Board of Supervisors on January 30 disbanded the Los Angeles County Smoke and Fumes Commission and discharged its five members who had served for the past 15 months.

In discharging the Smoke and Fumes Commission, the board pointed out there are two phases to the nuisance, black smoke and invisible gas. It was the opinion of the board that no scientific knowledge or equipment is needed to deal with black smoke, but that technical experts should be called upon to cope with the problem of invisible gases that pollute the atmosphere.

In another approach to the problem the industrial zoning committee of the Los Angeles Chamber of Commerce requested the Navy for the use of blimp in making tests of fumes which pervade the city and which have baffled experts seeking to fix the blame for them.

DBMA Elects Leach

BOSTON—E. C. Leach, general manager of the Lynn Products Company, was elected president of the Distilate Burner Manufacturers Association at its annual meeting held here recently.

Other officers elected for the ensuing year are: J. W. Meyer, Jr., Alaska Freezer Co., Winchendon, Mass., first vice-president; George Brumm, Oil Burner Products, Worcester, Mass., second vice-president; Henry H. Morse, Florence Stove Co., Gardner, Mass., secretary; E. T. Isaac, Cronin Supply Co., Cambridge, Mass., treasurer.

Dresser Industries Opens Cleveland Office

CLEVELAND—New centralized administrative offices of Dresser Industries, Inc., formerly of Bradford, Pa., were opened March 19 at 1130 Terminal Tower, Cleveland. The new offices will reduce executive travel time to the company's 18 different plants by providing a more central location for the company's headquarters.

Dresser Industries, Inc., parent corporation of 13 member companies, has laid out its 5,800 square feet of space in the Terminal Tower to provide modern conference space, reception room, and executive suites, in addition to 14 offices for the accommodation of its staff.

Newest members of the Dresser Industries group as recently announced are Payne Furnace Co., and Kobe, Inc., both of California. Another company, Day & Night Mfg. Co., also of California, is now in the process of acquisition.

Ultraviolet Lamps Aid Poultry Industry

NEW YORK—Where air-borne bacteria are the cause of illness or mortality, or where the reduction or elimination of bacteria will reduce spoilage, Sterilamps can be used to advantage, according to a paper by L. B. Veloz, Sterilamp specialist Westinghouse Lamp Division, New York, and presented before the Third Wartime Conference of the North Atlantic Section, American Society of Agricultural Engineers recently. Some specific benefits are as follows: battery capacity increased 25%; chick mortality reduced 50% to 70%; feathers develop faster and the plumage is better; combs are deep red and erect; pigmentation of the legs appears sooner and is more noticeable; culls and runts are greatly reduced; birds can be marketed up to two weeks sooner; and egg production is increased 10 to 15%.

Dr. T. C. Byerly, Senior Poultry Husbandman, United States Department of Agriculture, in a talk before the Poultry Industry Conference on July 26, stated that the poultry industry loses $150,000,000 a year due to the ravages of disease. This represents a cost of two cents on every dozen eggs produced and two cents on every pound of poultry produced. In all phases or stages of this business, in the hatching, brooding, raising and egg laying, there is one common problem involved which is not overcome by good housekeeping or sanitary techniques. This is the preventing or reducing the air-borne cross infection between the chicks or flock, which is so largely responsible for the epidemic spread of disease in poultry houses.

Sterilamps, when properly installed in the hatching compartment, reduce to a minimum the possibility of cross contamination between the hatching chicks due to the rapidly circulating air within the hatching compartments. The use of these same lamps is also recommended in the incubator room because, in the great majority of the cases, contaminated air from the hatching compartments is exhausted into this room which serves as a fresh air supply for the incubator. An equally important reason is that this highly contaminated air can act as a source of infection for the rest of the plant. It is further recommended that the lamps be used in the sexing, shipping, and sorting room for the complete protection of the chicks against air-borne infection until they are shipped. Hatchery men, who have used these lamps, say they have materially increased the viability of their chicks resulting in good will for them and a considerable saving as well.

Government bureaus have found that 60% of all chick mortality occurs within the first 16 days. This is during the nursing or brooding stage, which in many plants is combined with the raising to broiler size. Whether raised on the floor or in batteries, the acute congestion during the first two to four weeks of a chicken's life, offers an ideal opportunity for the rapid spread of air-borne disease. The germ killing rays of the Sterilamp continually disinfect the air, thereby providing the utmost in protection against the spread of air-borne epidemics.

NDHA Cancels Meeting

PITTSBURGH—The annual meeting of the National District Heating Association scheduled for June 13 and 14 at the Hotel Cleveland, Cleveland, Ohio, has been cancelled. Instead the Executive Committee of the society will meet at the hotel on these dates to dispose of current business. The society will collect reports of the various committees, and will have them printed in advance of the proceedings.

EMPLOYMENT SERVICE FOR VETERANS

Position-wanted advertisements in HEATING AND VENTILATING are available without charge to returning veterans seeking positions in engineering capacities in heating, air conditioning, ventilation, piping and refrigeration. The advertisement should not exceed 25 words; identities will not be revealed. Address the Editor.

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TUBE-TURN welding fittings contribute to longer life for any piping system in which they are used—by their greater strength, their smooth walls of uniform thickness, and their resistance to wear and corrosion. Welded piping connections are permanently tight and leakproof, and the whole system becomes virtually a single pipe. Threading, caulking, gasket replacement and bolt tightening are eliminated, thus doing away with potential causes of trouble in systems where other type fittings are used.

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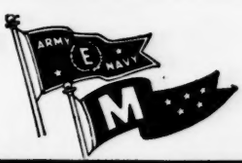
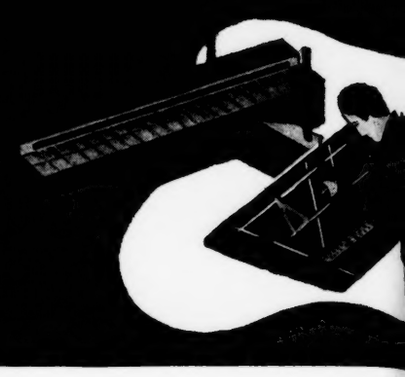


REVIEWS



Articles are abstracted for the convenience of the readers. Orders cannot be taken for the full length articles. Those desiring to obtain copies of the article referred to should write to the publishers of the respective articles.

EXHAUST HOODS

One of the most important variables in the design of exhaust ventilating systems is the size of the exhaust hood. Considerable data are available and great attention has been paid to the selection of the fan and design of the ductwork itself, but painstaking care with such details can easily be lost if the hood is not properly designed. If the air velocity through the hood is too low to carry the dust or to draw the fumes from the tank, the system may fail to function; on the other hand, if the hood is too small, losses are excessive and the system is uneconomical.

Probably the most complete exposition on exhaust hood design for efficient removal of duct fumes, vapors and gases is the series of articles by J. M. Dalla Valle, which appeared in HEATING AND VENTILATING during 1943 and 1944. These articles have been collected and published as a booklet, just published, so that the data, formulas and practical examples showing exact procedure are available in permanent form.

The book consists of twelve chapters as follows: Theory of Flow of Gases Into An Opening; Velocity Characteristics of Unobstructed Openings; Velocity Contours of Hoods With Special Boundary Conditions; Criteria for Determining Hood Effectiveness; Hoods for Dust Control: Total Enclosures and Screening; Hoods for Dust Control: Partial Enclosures, Miscellaneous; Hoods for Control of Fumes, Mists, Vapors and Gases; Booth-Like Structures for Fumes, Vapors and Gases; Grille-Type Openings Under Suction; Hood Entrance Losses; Examples of Calculations Required in Designing Hoods.

Exhaust Hoods, by J. M. Dalla Valle. Paper Covered, 49 pages, standard size. Published by HEATING AND VENTILATING, *148 Lafayette Street, New York 13, N. Y. Price, $1.00.*

WARM AIR HEATING

Section No. 7 of the National Warm Air Heating and Air Conditioning Association's series on practical warm air heating and entitled "Code and Manual for the Design and Installation of Warm Air Winter Air Conditioning Systems," has recently been published. The manual relates to structures having design heat losses under 150,000 Btu per hr.

Included are procedure for determining the Btu heat loss from rooms, a table of data on outside air temperatures for estimation, six pages of heat loss coefficients, and insulation data, together with a solution of a typical example of heat loss calculations; a number of pages are devoted to selection of furnace sizes, blower size, location of registers and intakes, together with the outline of procedure for making plant layout. Equivalent length of numerous warm air duct fittings are given, as are capacity tables for warm air and return air branches. The method of calculating the entire duct system is thoroughly treated. Shortcut data for estimating insulation and heat loss through windows are also presented. The book closes with a suggested ordinance for warm air winter air conditioning, and standards of the National Board of Fire Underwriters relating to warm air furnaces.

Book is loose leaf punched, standard size, the fourth of a series so far to appear. Previously released sections are as follows: Section No. 1, How to Make a Comfort Survey; Section No. 2, How to Check Frame House Construction; and Section No. 8, Yardstick for Classifying Warm Air Winter Air Conditioners (new revised edition). The books have been prepared by S. Konzo and G. A. Voorhees, editors, and all are priced at 50c. Obtainable from the Association, 145 Public Square, Cleveland 14, Ohio.

CONVECTOR DATA

Frederick E. Giesecke and Alonzo P. Kratz are the authors of University of Illinois Bulletin Series 356 entitled "Heat Emission and Friction Heads of Hot-Water Radiators and Convectors."

The investigators studied the effect on heat emission rates and friction heads of the type and size of the unit; size of pipe connections; type of pipe connections; and velocity and temperature of water.

Following their investigations, completely described in the 52-page booklet, the authors arrived at the following conclusions which applied to the test data and the conditions under which the tests were conducted: (1) The friction head produced by the water flowing through a radiator or convector may be divided into three parts, namely, the friction head at inlet, the friction head at outlet, and the friction head within the unit itself. Of these three friction heads, the friction head at inlet is the greatest; the friction head at outlet is intermediate; and the friction head in the unit is the smallest except in the case of very long units. For the 4-tube radiators tested with ½-in. pipe connections, it was found that the sum of the friction heads at inlet and outlet varies as the 2.18 power of the rate of flow of the water, and that the friction head in the body of the radiator varies directly as the length of the radiator and directly as the 1.54 power of the rate of flow of the water. The formula developed for this case is

$$H_f = 0.000395P^{2.18} + 0.001125P^{1.54}S \qquad (37)$$

in which

H_f = friction head in milinches of water,
P = rate of flow of water through the radiator in lb per hr, and
S = number of sections per radiator

(2) The sum of the friction heads at inlet and outlet in the case of convectors is practically the same as that for radiators, since there is practically no difference in the course of the water through these two types of units.

(3) The friction head produced within a radiator or convector is determined by the shape, size, and length of the passages through which the water flows.

(4) For a given rate of flow of water, the size of the connection has an important influence on the friction heads at inlet and outlet and, therefore, also on the overall friction head. For example, using the friction head for a 1¼-in. connection as the basis, the friction head for a 1-in. connection would be about four times as large, and that for a ½-in. connection about twelve times as large.

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These large differences may be explained as follows. If a ½-in. pipe and a 1-in. pipe are to supply water to a radiator or convector at the same rate, the velocity of the water in the ½-in. pipe must be 2.84 times the velocity in the 1-in. pipe; the kinetic energy of the water in the ½-in. pipe will then be eight times that of the water in the 1-in. pipe. As the water enters the radiator or convector, its velocity is reduced and the kinetic energy of the stream of water is transformed partly into pressure head and partly into heat. The latter portion constitutes a total loss insofar as the pressure head produced by the flowing stream of water is concerned.

(5) The differences between the friction heads for end and bottom connections of the two convectors tested were so small that they may be considered negligible. In both cases, the friction heads for bottom connections were slightly smaller at low water velocities and slightly larger at high water velocities.

(6) The effect of an increase in the temperature of the water is to reduce the friction head in the radiator or convector.

In the case of the cast-iron convector it was found that increasing the water temperature from 66F to 220F resulted in a reduction of about 40% in the friction head.

In the case of the non-ferrous convector it was found that increasing the water temperature from 68F to 170F resulted in a reduction of about 14% in the friction head.

(7) For the purpose of design, it is best to express the friction head of a radiator or convector in terms of elbow equivalents or velocity heads.

The value of the friction head of a radiator, expressed in elbow equivalents or velocity heads, ranges from about two for a short radiator with ½-in. connections and a high velocity of the water to about six for a long radiator with 1¼-in. connections and a low velocity of the water.

(8) The friction head of a *long* cast-iron convector, expressed in elbow equivalents or velocity heads, varies from about three for a convector with ½-in. connections and a high velocity of the water, to about six for a convector with 1¼-in. connections and a low velocity of the water.

(9) The friction head of a *long* non-ferrous convector, expressed in elbow equivalents or velocity heads, varies from about three for a convector with ½-in. connections and a high velocity of the water, to about eleven for a convector with 1-in. connections and a low velocity of the water.

(10) For convectors which are shorter than those included in these tests, the friction heads are, no doubt, smaller.

(11) For the majority of the cases occurring in practice, it is sufficiently accurate to assume the friction head of a radiator or convector as equal to that of three standard 90-degree screwed elbows, or to three elbow equivalents. If the water velocity, V, is expressed in inches per second, the friction head of one radiator or convector is $3.88V^2$ milinches of water.

Paper bound, 6x9 in., 52 pages. Published by The University of Illinois, Urbana, Ill. Price 50c. Limited numbers of copies available for free distribution.

STOKER MANUAL

The Stoker Manufacturers' Association, through its engineering and research committee, has published a "Technical Manual on Industry Standards, Recommended Practices and Technical Information," for distribution to those interested in selection and application of mechanical underfeed stoker equipment.

The manual has been designed to assist engineers in the stoker industry as well as consulting engineers, smoke abatement officials, heating contractors, and technicians associated with industries allied with the stoker industry, by having available for practical use and reference authentic and reliable stoker data for use in the selection, sizing and application of stoker equipment to various types of furnaces and boilers and heating loads.

The manual is composed of eight separate sections covering: (1) Glossary of terms, defining the phrases and terminology used in the manual; (2) Selection factors to be considered in the selection of stoker equipment and boilers or furnaces for stoker firing; (3) Condensed table of all the various selection factors; (4) Standard codes and recommendations established during the past several years by the Stoker Manufacturers' Association; (5) Chimney data incorporating recognized information on sizes and heights of chimneys and smokestacks reprinted from current engineering guides; (6) stoker nomenclature; (7) Coal data covering bituminous and anthracite coals, and (8) Miscellaneous, including descriptive sheets showing care and operation of commercial and industrial underfeed stokers, and complete tables showing areas in square feet of rectangles and areas of circles.

Sixty pages, 8½x11, printed, paper-bound, inside pages punched for loose-leaf filing. Available from Stoker Manufacturers' Association, 307 North Michigan Avenue, Chicago 1, Ill. Price, single copy, $1.00. The Association, however, will furnish single copies free to registered architects, consulting engineers, other professional men writing on the letter-head of individual or firm.

ENGINEERING STANDARDS

The Heating, Piping and Air Conditioning Contractors National Association has just published Parts III and V of the Fourth Edition of its Engineering Standards.

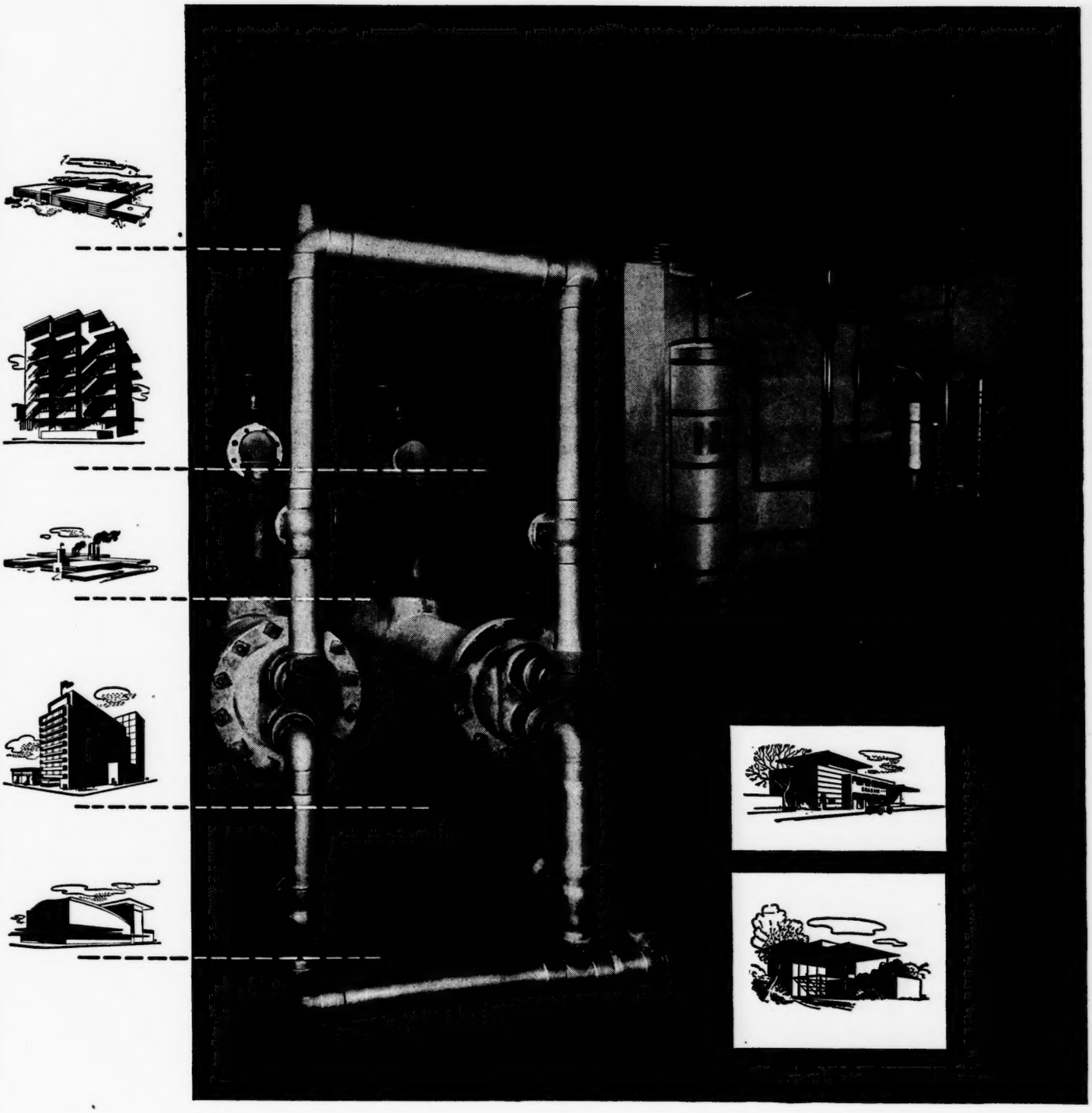
Part III, on Pipe Sizes and Design, is a 36-page booklet devoted to the sizing of pipes for steam heating and vapor systems, for gravity hot water heating systems, and for mechanically circulated hot water heating systems. In addition to the tables giving the necessary data for sizing pipe there are ten pages of plates showing piping details, typical layouts for the piping of heating systems and proper hook-ups for unit heaters. These drawings were developed in cooperation with the Unit Heater Manufacturers Association. On one of the unit heaters a table is given for the ratings of low pressure float and thermostatic traps which is a standard adopted by the Steam Heating Equipment Manufacturers Association.

Part V, containing Graphical Symbols for Use on Drawings and Scheme for the Identification of Piping Systems, is material developed under the procedure of the American Standards Association. In the section on graphical symbols, the symbols used on drawings for piping systems, heating and ventilating systems, ductwork, and refrigerating systems are included. The identification of piping systems gives the scheme for identification by color and by legend and also the classification of materials.

Available from the Heating, Piping & Air Conditioning Contractors National Association, Suite 1401, 1250 Sixth Ave., New York 20, N. Y.

INSULATION AND STORM WINDOWS

Bulletin Series No. 355 of the University Experiment Station of the University of Illinois entitled, "Fuel Savings Resulting From Use of Insulation and Storm Windows," has appeared under the authorship of Alonzo P. Kratz and Seichi Konzo. This bulletin, which is a report of the investigations conducted by the Experiment Station of the University in cooperation with the National War-Air Heating and Air-Conditioning Association, shows that in severe weather a saving of 22% in the fuel required to heat the uninsulated warm air heating research residence in Urbana was effected by the use of storm windows and a storm door. The actual savings were about 0.81 of the estimated savings based on the calculated heat losses from the building. Further advantages effected by the use of storm windows in



COPPER MAKES ANY BUILDING BETTER

No matter how you look at it, a copper tube installation improves a building. Not only by keeping heating and water lines clean on the inside—for unobstructed flow and clear water—but also by slowing depreciation. Any open-minded owner will easily understand why the use of copper lines saves him money. What's good for buildings and their owners is good for the engineer and contractor. You can rely on copper to back up your professional reputation.

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Designed for heating, air conditioning, water supply and other services, this tube is stamped with the Revere name and the type at regular intervals. Look for these identification marks—they insure full wall thickness and the close gauge tolerances that are so necessary for tight sweated joints.

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cluded a reduction in the amount of cold air in leakage and downdrafts of air over the windows, thus resulting in greater comfort; the elimination of condensation appearing on the windows in severe weather when comparatively high relative humidities were carried; and the elimination of soot leaking in at the cracks around the sash.

Use of 5⅝-in. thickness of mineral wool insulation in the Residence, without the addition of storm windows, resulted in an actual saving of approximately 30%, or about 0.78 of the estimated savings based on the calculated heat loss from the Residence. When both storm windows and insulation were used, the actual savings amounted to 45%, or about 0.68 of the estimated reduction. As the heat loss from the Residence was progressively reduced, the ratio of the percentage of actual saving to the percentage of estimated saving became smaller. A possible explanation is offered in the bulletin. Further advantages resulting from the use of insulation included a marked increase in the inside surface temperature of the insulated walls, with a corresponding increase in comfort, a reduction in flue gas temperatures; and a reduction in time of operation of the stoker motor and fan motor.

A summary of the conclusions reached and which of course apply only to the residence under the conditions under which the tests were conducted are as follows:

(1) A seasonal fuel saving of the order of 20% was obtained by completely equipping the uninsulated Research Residence with storm windows and a storm doors. The actual saving effected by storm windows and a storm door, as determined by test, was about 0.81 of that estimated from the calculated heat losses.

(2) For a given type of wall construction the fuel saving effected by storm windows and doors is dependent on the ratio of the total area of the windows and doors to the net area of the walls. The potential savings increases as this ratio becomes greater.

(3) Tightly fitting storm windows practically eliminated the entrance of objectionable amounts of soot.

(4) Storm windows made possible the maintenance of higher indoor relative humidities without condensation appearing on the glass.

(5) Use of storm windows reduced the draft of cold air down the windows and increased the temperature of the air near the floor in the room.

(6) Use of storm windows increased the temperature of the inside surface of the glass and resulted in an increase in comfort.

(7) Installation of insulation in the Residence not equipped with storm windows resulted in an average saving of approximately 30% in the actual fuel consumption, or about 0.78 of the estimated reduction based on calculated heat losses.

(8) At an indoor-outdoor temperature difference of 80F, the temperature of the inside surface of the exposed walls was increased approximately 11.0F by the application of insulation, thus resulting in a material increase in comfort.

(9) Installation of both storm windows and insulation in the Residence resulted in an average saving of approximately 45% in the actual fuel consumption, or about 0.68 of the estimated reduction.

(10) As the heat loss from the Residence was progressively reduced, the deviation of the actual savings from the estimated reduction in heat loss became larger. This deviation was attributed to uncertainties accompanying the calculation of heat losses, particularly those for infiltration, and to the use of an oversized furnace as the heat loss was reduced.

(11) Electrical inputs per day to the stoker and fan motors were each decreased from 25 to 30% after the house was insulated, as compared with the results obtained in the uninsulated house.

(12) The estimated reductions, in heat losses indicated that a greater benefit was obtained from the insulation of the upper stories than from that of the first. This was confirmed by the fact that temperatures on the second story were from 1 to 3F higher, and those on the half-story were from 5 to 7F higher, after the installation of insulation and before final adjustment of dampers, than they were in the uninsulated house.

(13) Installation of insulation and storm windows without changes in the heating system was equivalent to the use of an oversized furnace. In spite of this, no difficulties were encountered from overheating or from lack of uniform temperature distribution in the rooms, and the results may be considered as representative of those arising from the common practice of insulating the house without changing the heating plant.

Paper covered, 6x9 in., 40 pages. Published by The University of Illinois, Urbana, Ill. Price 40c. Limited supply available for free distribution.

BRIEF REVIEWS

HEAT AND HUMIDITY IN INDUSTRY—A 56-page reprint from The Journal of Industrial Hygiene and Toxicology entitled, "The Control of Excessive Heat and Humidity in Industry", by John B. Skinner and W. M. Pierce, both of the Massachusetts Division of Occupational Hygiene, and reporting a study of working conditions made in 31 plants where hot processes are employed during summer months. The authors found that under the worst average expected conditions, 39 out of 52 workrooms would exceed the "maximum permissible effective temperature" of 86F. The authors report that common faults in control measures included exposure of inlet pipes to heated air, introduction of inlet air from hot rooms and reduction of fan efficiency by the opening of nearby windows. A misconception occasionally encountered was the belief that supply and exhaust ventilation rates are additive.

BUTANOL—A 3-page reprint from The Journal of Industrial Hygiene and Toxicology entitled "Industrial Exposure to Butanol" and appearing under the authorship of Irving R. Tabershaw, John P. Fahy and John B. Skinner, all of the Massachusetts Division of Occupational Hygiene. The toxicity of butyl has not been clearly defined and the paper reports a study of experience in six different plants where this material was used. Eye irritation occurred with concentrations of butanol as low as 40 ppm and many individuals find the odor disagreeable above 25 ppm. The authors concluded that in general butanol concentrations below 50 ppm produce no important effects.

STOKERS—Simultaneously with the announcement of the release of the SMA Stoker Technical Manual by the Stoker Manufacturers Association, a four-page folder containing a consolidated table on the factors for the selection of stoker equipment as reprinted from the new engineering handbook was made available by the Association. This table, together with explanatory notes, contains essential and basic engineering and technical data covering load carrying capacities of various size stokers ranging from 15 to 1200 lb of coal per hour and the Association's recommendations as to setting heights, boiler and furnace minimum widths and lengths, together with condensed data on chimney sizes. Single copies available from Stoker Manufacturers' Association, 307 North Michigan Ave., Chicago 1, Ill., at 5c per copy.

INDUSTRIAL HYGIENE—A 13-page review of Industrial Hygiene in 1944. Mention is made of the work done during that year on aluminum therapy for silicosis, studies made no pneumoconiosis, the welding hazard, and troubles arising from the use of lead and radium. Reprinted from the New England Journal of Medicine. Under the authorship of Irving R. Tabershaw, and Manfred Bowditch, both of the Massachuetts Division of Occupational Hygiene.

The sheet shows its stuff

Bethlehem Steel Sheets have made a lot of friends during this war. Men who work with all kinds of sheets—sheet-metal contractors, heating and ventilating contractors, makers of formed products—have found that Bethlehem Steel Sheets saved them time, trouble and money, on jobs that have been much more tricky and demanding than are normally encountered in peactime experience.

Yes, these sheets have shown plenty of stuff—uniform quality and dependability—ease in forming and seaming—ability to take deep-draws much more drastic than were believed possible a few years ago.

Plan to use Bethlehem Sheets for your postwar contract work or products. There's a Bethlehem Sheet which will suit your needs—and do its job with ease and efficiency.

BETHLEHEM STEEL

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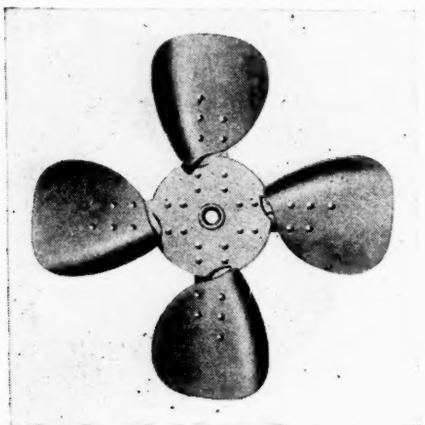
NEWS OF EQUIPMENT AND MATERIALS

Attic Fan Blades

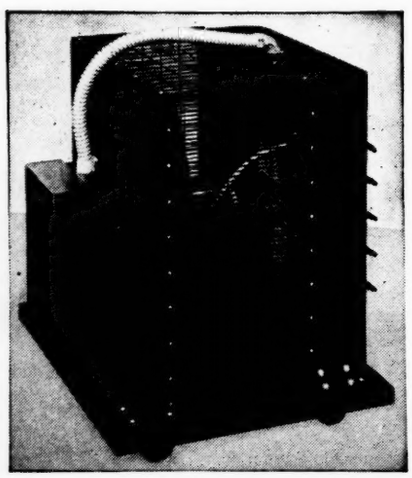
NAME—Torrington series B attic fan blades.
PURPOSE—Redesign of the company's A series blade.
FEATURES — Efficiency has been improved; identical proportions, proved aero-dynamically correct, are adhered



to in all diameters. A larger center disc and heavier spider arms increase strength. A new blade shape adds to the appearance. Entire line is of all steel construction.
SIZES AND CAPACITIES—Available in either 3, 4, or 5 blades in standard diameters of 24, 30, 36, 42 and 48 in.
LITERATURE AVAILABLE — Temporary bulletin.
MADE BY—*Torrington Mfg. Co., Torrington, Conn.*

Portable Heater

NAME—Portable air heater.
PURPOSE—For locations where heat is required only at certain periods.
FEATURES—Designed originally for heating emergency huts to protect men working outdoors in a steel plant. Heater elements, fan motor, contactor and switch are all mounted on one base with casters for easy mobility. In the 20 kw heater shown,



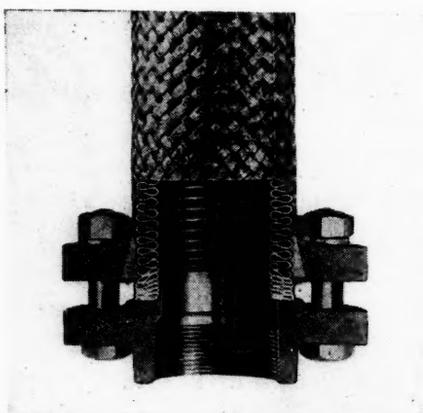
standard Electromode rectangular heater elements are used consisting of sheathed resistors cast in one-piece finned aluminum castings.
MADE BY — *Electric Air Heater Co., Mishawaka, Ind.*

Radiamatics

NAME—Radiamatic.
PURPOSE—Five improvements in the company's compensated radiation pyrometer.
FEATURES—Five improvements are: (1). Use of an adhesive sealing compound between lens and mounting ring; (2). Use of brass for lens retaining and mounting rings; (3). Controlled torque is applied when assembling lens retaining and mounting rings; (4). Two spanner wrench holes in lens mounting ring face have been replaced with milled slot which avoids cutting through ring face, and, (5). Use of a more positive sealing, with an improved adhesive, of sighting glass located in rear of thermopile assembly. Other improvements include use of aluminum instead of cast iron for Radiamatic housing.
MADE BY — *Brown Instrument Co., Philadelphia, Pa.*

Fitting for Metal Hose

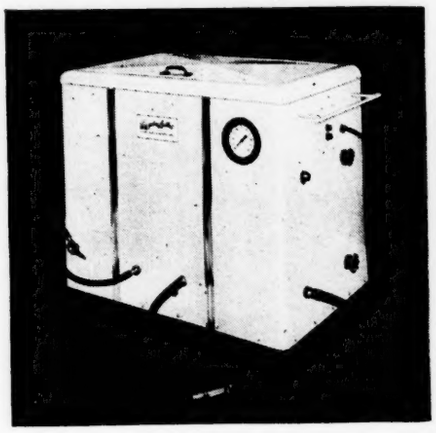
NAME—Detachable flange for helical flexible metal hose.



PURPOSE—To make possible flanges on lengths of flexible metal hose.
FEATURES—It is designed to permit reuse. The fitting makes a metal to metal seal without any gasket. No brazing is required.
SIZES AND CAPACITIES—For sizes 2, 2½, and 3 in. I.D.
LITERATURE AVAILABLE — Instruction sheet, which by means of 19 photographs, shows the steps required to assemble the flange.
MADE BY — *Packless Metal Products Corp., New Rochelle, N. Y.*

Precipitron Cleaner

NAME—Hydra Lectric Unit.
PURPOSE—A unit to clean the Westinghouse Precipitron.
FEATURES—Machine delivers a hot emulsifying solution at the nozzle at 5 gpm and 300 lb pressure to reach clear through the back of the col-



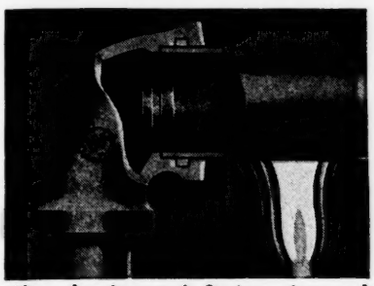
lector plates. The adhesive film is rapidly emulsified by the action of the chemical solution and the dirt is loosened from the plates. After the cells have had time to dry, about 30 minutes, the unit is used to apply a new adhesive coat to the precipitron plates. Unit has a 16-gallon tank for the cleaning chemical in concentrated solution, and a 10-gallon adhesive tank.
MADE BY—*Hydra Lectric Products Corp., Indianapolis, Ind. Distributed by Westinghouse Electric Elevator Co., Precipitron Dept., Jersey City, N. J.*

Hose Clamp

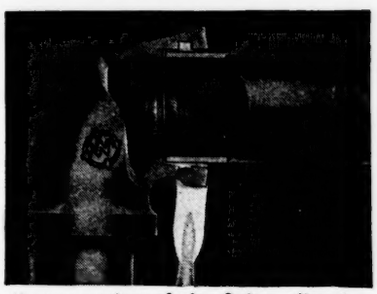
NAME — Wittek type WWD hose clamp.
PURPOSE—Hose clamp for protecting hose from serrations in outer band and distributing load uniformly.
FEATURES—An improved worm drive type, made of stainless steel.
SIZES AND CAPACITIES—Available in eight adjustable sizes to cover entire range of applications.
MADE BY — *Wittek Manufacturing Co., Chicago 23, Ill.*

Facts you should know about Silbraz* joints

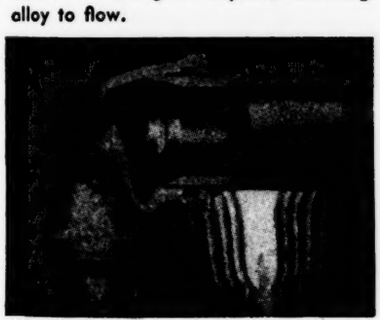
for copper or brass pipe lines



After cleaning and fluxing pipe and fitting, insert pipe into fitting up to shoulder. Then expand pipe by heating with the oxyacetylene flame.



Heat a section of the fitting, directing flame toward pipe or tubing. This causes section of fitting to expand, allowing alloy to flow.



Heat both pipe and fitting with a wiping motion of torch. Remove flame. Fitting contracts, alloy flows and forms ring at fitting edge, completing Silbraz joint.

Increasing demands for "one-piece" copper and brass pipe lines make it essential that plumbing and heating contractors be fully familiar with Silbraz joints . . . the threadless method that actually bonds the pipe and fitting into a single unit.

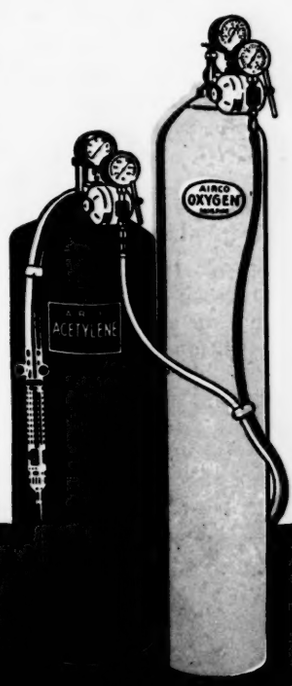
The Silbraz joint gets its name from the silver brazing alloy that is incorporated into the ports of valves and fittings. When heated with an oxyacetylene torch, this alloy melts, makes a tight, *permanent* Silbraz joint — stronger than the pipe itself.

Silbraz joints are highly resistant to shock, vibration and corrosion . . . and no properly made Silbraz joint has ever been known to leak. It is easy to identify a correctly made Silbraz joint by the fillet of silver brazing alloy at the fitting where it joins the pipe.

In recognition of the value of these leakproof, permanent connections, leading manufacturers are producing Silbraz valves, flanges and fittings in sizes to meet the many requirements of plumbing, heating, fuel, gas and process pipe lines.

For the proper equipment and supplies to correctly install Silbraz joints, see your nearby Airco office. They will be only too glad to help you select the right torch and necessary tips.

* Reg. U. S. Pat. Off.



AIRCO

AIR REDUCTION

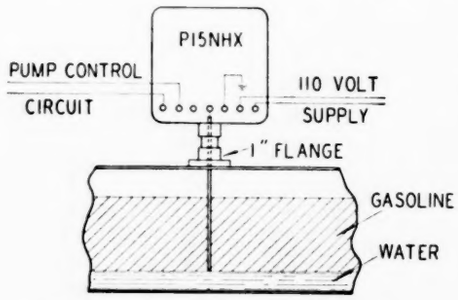
General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

In Texas: MAGNOLIA GAS PRODUCTS CO. • General Offices: HOUSTON, TEXAS

Offices in All Principal Cities

Water Detector Lock

NAME — Type P15NHX electronic water detector lock.
PURPOSE—Detects presence of water



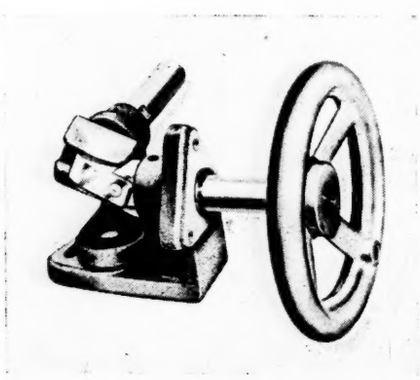
in gasoline storage tanks and automatically locks pumping equipment against further operation.
FEATURES—As shown in accompanying sketch, device is mounted directly on 1 in. flange which is installed at top of storage tank which provides support for unit. A probe rod with 1 in. nipple at top is screwed into housing and projects into tank to level at which water detection is required. When rising water contacts tip of probe, relay opens and shuts down pump motor. Motor cannot be restarted until water is removed. Current failure will cause lock to operate.
MADE BY — *Photoswitch, Inc., 77 Broadway, Cambridge, Mass.*

Control Timer

NAME—Reco control timer.
PURPOSE—For controlling manufacturing operations in which starting is initiated by momentary contact push button, stopping automatically at pre-set time.
FEATURES—Equipped with silver contacts and two circuit controls.
MADE BY—*Reynolds Electric Company, 2650 W. Congress St., Chicago 12, Ill.*

Link Joint for Valves

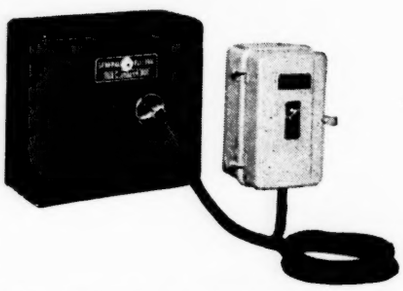
NAME—Piezo universal link joint.
PURPOSE—For transmitting rotary motion around corners for such applications as valve operation.



FEATURES — Permits operation of shafts at angles adjustable from a straight line, 0° automatically to a right angle, 90°. Output shaft turns in exact angular rotation as input shaft, giving an input turning angle equivalent to output turning angle, which is of importance in dial settings and where uniform motion is desired. Joint is mounted by means of three screws which hold it in position. The bearing arm which holds the adjustable shaft may be hinged to any desired position from 0° to 90° and when in its proper location a locking screw permanently holds its position.
LITERATURE AVAILABLE—Bulletin No. 45.
MADE BY—*Piezoelectric Corp., 110 E. 42nd St., New York 17, N. Y.*

Hay Drier Control

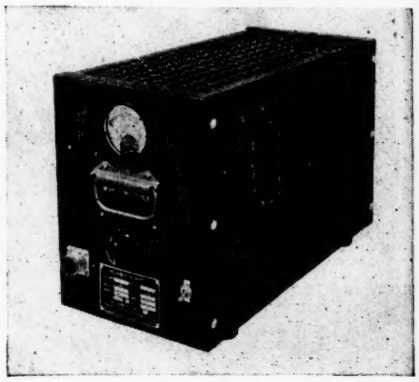
NAME — G-E control for barn hay driers.
PURPOSE — Control turns on or off blower thus maintaining a cool temperature in the hay so as to avoid fire.
FEATURES — Consists of magnetic starter, time switch, and thermostat



if required, to operate either 3- or 5-hp, 230-volt, 60-cycle single-phase motors such as SCR type. Control equipment to operate motors of larger and smaller ratings will be available later. Magnetic starter, either manually or automatically operated, is equipped with selector switch with on, off, and automatic positions. Time switch, with three sets of riders, is used primarily at night to start and stop blower periodically if humidity is too high. Three on and off predetermined operations are possible in a 24-hour cycle. Both 2- and 3-pole receptacles are a feature of new control. Three-pole receptacle is for time switch plug and 2-hole is used for plugging in a remote control lead, or thermostat. Complete hay-drying outfits consist of a motor-driven blower with proper control and air ducts laid on floor of hay loft in existing barns. Control practically eliminates spontaneous combustion, which has been a constant threat where hay is stored in a building.
MADE BY—*Farm Industry Div., General Electric Co., Schenectady 5, N. Y.*

Power Rectifier

NAME—Regulated voltage power supply FTR—3128-S.
PURPOSE—To provide a portable, well-



regulated d-c power supply unit.
FEATURES — The company's selenium rectifier is used, and it operates from a single phase a-c input or 115 volts, 58 to 62 cycles. It provides d-c power up to 10 amperes at any selected voltage between 22 to 30 voltages. Output voltage is automatically held constant to within plus or minus 0.5 volt regardless of load variation from 0 to 10 amperes, or a-c line voltage fluctuations of 105 to 125 volts. The entire equipment, which weighs about 74 pounds, is enclosed in a black medium-wrinkle finish cabinet, 11¼x8x16 in.
MADE BY — *Federal Telephone and Radio Corp., Newark, N. J.*

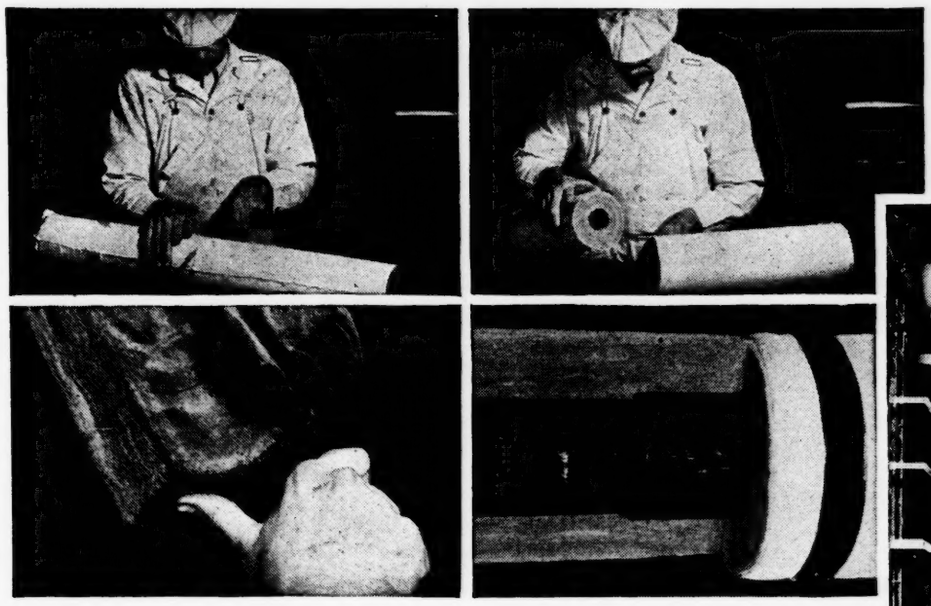
Plastilock Adhesive

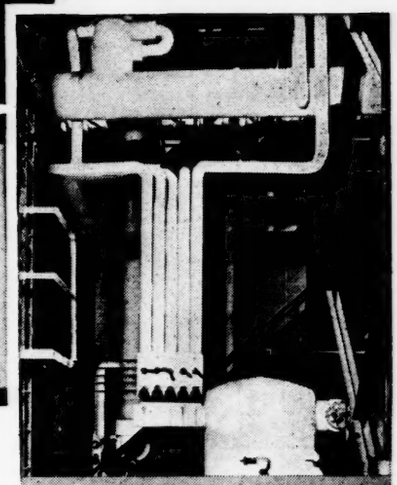
NAME—Plastilock 500.
PURPOSE—Adhesive for bonding metals, woods, plastics and ceramics to themselves or to each other.
FEATURES—Substance is a non-thermoplastic, water and aromatic oil-resistant adhesive said to provide superior bonding qualities in any applications and in some places can be used in place of rivets or screws. Has shown a shear strength of 3,250 lb per sq in. tensile strength of 4,000 lb per sq in.
MADE BY—*The B. F. Goodrich Co., Akron, Ohio.*

Series V Blowers

NAME—Viking series V blowers.
PURPOSE—For furnaces or air conditioning units.
FEATURES—Said to operate with an unusual degree of quietness. Designed to operate against high static pressures. Blower represents the reduction in overall size from 10 to 15% over previous models.
MADE BY — *Viking Air Conditioning Corp., 5600 Walworth Ave., Cleveland Ohio.*

★ easier-faster application





PF (Pre-formed) PIPE INSULATION

...another reason for using

FIBERGLAS*

Cut it and trim it and fit it to size—installing Fiberglas PF Pipe Insulation over couplings is as easy as that.

Made in three-ft. sections, lightweight PF is easy to handle. It can be cut with an ordinary knife to form a snug fit with minimum loss of insulation thickness and efficiency. Couplings are invisible when work is finished. The fibrous ends of the sections intermesh to form tight joints.

In co-operation with the Government program to save critical fuel.

Fiberglas PF Pipe Insulation is made of fine glass fibers bonded with a thermosetting binder and molded into standard sections and segments. It is used for steam and other hot lines up to 30" O.D. with temperatures up to 600° F.

The unusually low thermal conductivity of PF results in significant savings in heat and power. Fiberglas does not rot or decay, disintegrate or pack down under vibration. And because of its mechanical strength, this pipe covering holds its shape, withstands handling and is easily applied even on the larger pipes where three segments are used.

For complete information about Fiberglas Pipe Insulations and the many other uses of Fiberglas, write for the booklet "Fiberglas Insulations for Industry," *Owens-Corning Fiberglas Corporation, 1841 Nicholas Building, Toledo 1, Ohio. In Canada, Fiberglas Canada Ltd., Oshawa, Ontario.*

FIBERGLAS INDUSTRIAL INSULATIONS

1. Blanket Type Pipe Insulation—With mesh wire on outer side to wrap around pipe and secure with wire through special edging. Manufactured in 2-ft. sections for pipes over 3" O.D. Will withstand temperatures up to 1000° F.

2. Metal Mesh Blankets—With mesh wire or expanded metal on one or both sides. Lightweight and easily applied. 2 ft. x 4 ft. and 2 ft. x 8 ft. In standard thicknesses. Two types: For temperatures up to 600° F. and 1000° F.

3. No. 600 PF Block—Same materials as in PF Pipe Covering — in blocks 6" x 36" and 12" x 36", standard thicknesses.

4. OC-1800 High Temperature Block—A highly efficient molded block in sizes 3" x 18" and 6" x 36" and 12" x 36"—in standard thicknesses. Will withstand surface temperatures up to 1800° F.

5. Insulating Cement—For insulating fittings, valves and all irregular surfaces. Highly efficient . . . withstands temperatures up to 1200° Fahrenheit.

6. OC Mastic Finish—An asphalt emulsion cement for insulated pipe and equipment exposed to outdoor or high moisture conditions.

7. Insulating Wool, Type TW-F—Available in bats, rolls and bulk. Used for drying-ovens, heaters, etc., for filling irregular spaces.

8. PF Insulation—Manufactured in 5 densities from 2½ to 9 lbs. per cu. ft.—standard sizes 24" x 48", 1" to 4" in thickness, according to density. For insulated panels, sound absorption and various semi-structural applications.

9. PF Roof Deck Insulation—9 lbs. density with facing to facilitate mopping. Highly efficient, with incombustible, rotproof and moisture-resistant core, for application under industrial built-up roofings. Sizes 24" x 48". Thicknesses from $\frac{13}{16}$" to 2".

ARMY E NAVY

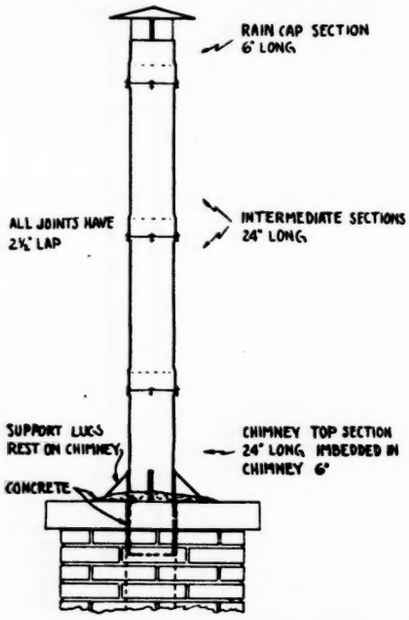
FIBERGLAS

*Trade Mark Reg. U. S. Pat. Off.

INDUSTRIAL INSULATIONS

Chimney Extension

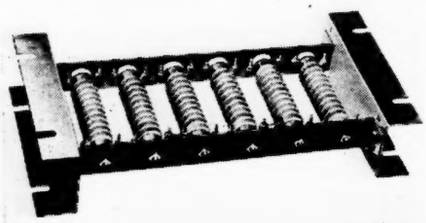
NAME—Vitroliner prefabricated porcelain enameled chimney extension.
PURPOSE—To increase height of brick chimneys with insufficient draft or downdraft.


RAIN CAP SECTION 6" LONG
ALL JOINTS HAVE 2½" LAP
INTERMEDIATE SECTIONS 24" LONG
SUPPORT LUGS REST ON CHIMNEY
CHIMNEY TOP SECTION 24" LONG, IMBEDDED IN CHIMNEY 6"
CONCRETE

FEATURES—Made of heavy gauge steel with two coats of acid-resisting porcelain enamel fused into steel. Extension requires no guy wires and can be equipped with rain cap or revolving ventilator cap. Extension can be made in approximately one-half hour, it is claimed. Installation is made by inserting the chimney top section into top of chimney with four support lugs resting on capstone or first layer of brick and grouting it into place with cement. Sections (24 in.) of Vitroliner may then be added to reach desired height.
MADE BY—*Condensation Engineering Corporation, 122 S. Michigan Ave., Chicago 3, Ill. The foregoing item is reprinted from the March issue of* HEATING AND VENTILATING, *in which the device was incorrectly credited to another manufacturer.*

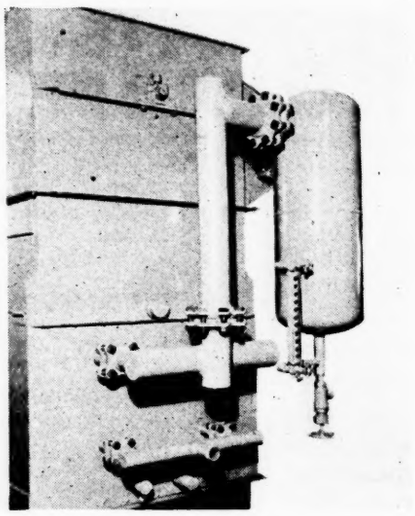
Bank-type Resistor

NAME—Regan Bank-type Resistor.
PURPOSE — To provide resistors in banks of 6 resistors or from 2 to 24.
FEATURES—Cores are made of glazed steatite. In the event that an element burns out, due to overloading, it is not necessary to tear down the whole assembly. One nut on each end of the defective resistor is unscrewed and a new element is wound around the core. For a 6-bank resistor, the dimensions are length, 23 in.; frame width, 11⅛ in.; frame depth, 4¼ in.
MADE BY—*Techtmann Industries, Inc., 828 N. Broadway, Milwaukee 2, Wis.*



Oil Remover

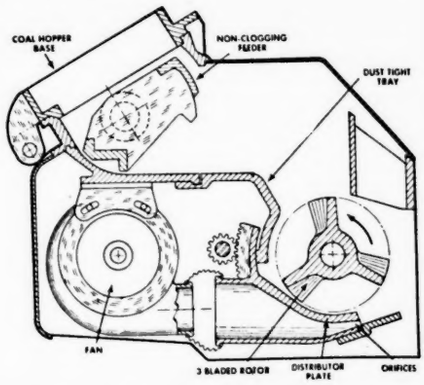
NAME—Niagara Oilout.
PURPOSE—To remove oil from refrigerant gas.
FEATURES—Refrigerant gas enters a drum at the outlet of the Duopass Coil with a tangential motion. Gas temperature is reduced by the coil so that the oil vapor is condensed. Expansion of the system from a 4 in. pipe to a 14 in. drum reduces the velocity of the gas so that the oil is removed and is held by the wall and separator plates of the trap. The device has a sight gauge and valve for draining the oil.



MADE BY—*Niagara Blower Co., 6 E. 45th St., New York 17, N. Y.*

Spreader Stoker

NAME—J & J spreader type stoker.
PURPOSE—For automatic coal burning in large installations.
FEATURES—Has sturdy, non-clogging, dust-tight coal feeder. Adjustable for various operating conditions. It is said positively to prevent spillage of fines along stoker. Three-bladed rotor receives coal from the feeder tray and discharges it into furnace off end of distributor plate, position and slope of which are adjustable to meet requirements of different size furnaces. A small high velocity fan mounted in back of rotor, and discharging through orifices under distributor plate, catches fines and distributes them in furnace. This is said to overcome tendency of fines to drool down on to furnace hearth, prevent segregation of fines on front grates and lump on rear grates. Exposed parts of stoker are air-cooled. Stoker unit is mounted on cast iron front with four hinge pins, two on each side.



SIZES AND CAPACITIES—Four standard sizes with 16, 20, 24 and 32 in. long rotors. Can be installed singly or as multiple units to meet requirements of boilers from 75 hp upward.
LITERATURE AVAILABLE — Descriptive bulletin.
MADE BY—*The Johnston & Jennings Co., 875 Addison Rd., Cleveland 14, Ohio.*

Copper Lined Tanks

NAME—American Welding copper-lined, porcelain enamel and steel water tank.
PURPOSE—Domestic hot water storage, home water systems and pump systems.
FEATURES—Copper is combined with base metal in such a way as to avoid galvanic action, porcelain enamel being used as an insulator between the steel tank and the copper lining. Metal bond coating applied to porcelain enamel serves double purpose of sealing any pin holes in the porcelain and of bonding copper lining to enamel. Binder is also an insulation against electrolysis and provides about same coefficient of expansion for tank liner and exterior.
MADE BY—*The American Welding & Manufacturing Co., Warren, Ohio.*

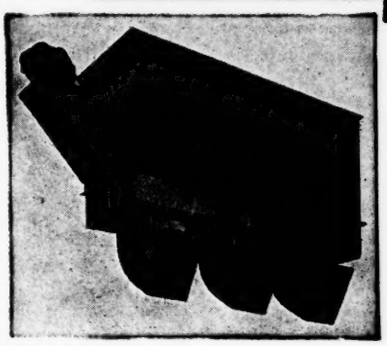
Insulating Varnish Selector

NAME—Insulating varnish selector.
FEATURES — From a list of varnish applications, the user selects the one for which he wants a varnish. After moving a slide until an arrow points to the chosen application, the selector shows the varnish number, data on its characteristics, type of base, recommended thinner, and baking or air-drying time. Seven varnishes are listed.
MADE BY—*Distributed free by any merchandise distributor of General Electric Co., Schenectady, N. Y.*

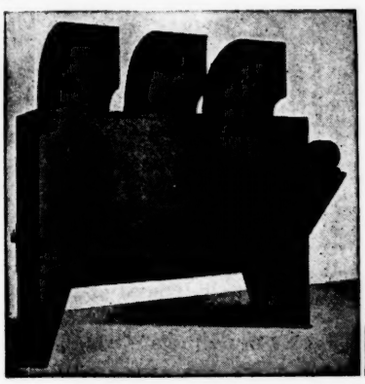
Available for Prompt Delivery—

THE AIRTHERM CENTRIFUGAL FAN TYPE, STEAM UNIT HEATER

(Vertical, Horizontal, or Floor Type Models)



Ceiling mounted, inverted type.



Floor mounted.

The Airtherm centrifugal, fan type, steam unit heater is a highly efficient heater for either vertical or horizontal suspension and is available to you for delivery during the present heating season.

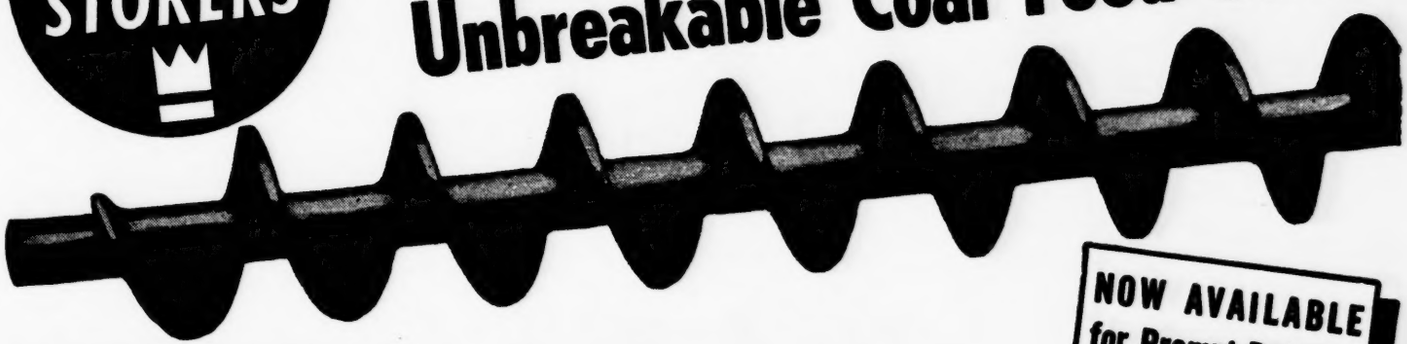
This high velocity unit insures uniform temperature distribution and maximum heat flow effecting savings in both fuel and maintenance cost. Capacities range from 200,000 to 825,000 B.T.U.

Send us your specifications or write for the Airtherm Catalog today. Our engineers will gladly work with you in planning efficient heat for your plant.

AIRTHERM
MANUFACTURING COMPANY
722 South Spring Avenue • St. Louis 10, Missouri

For STOKERS

The CROWN Unbreakable Coal Feed Screw



NOW AVAILABLE for Prompt Delivery

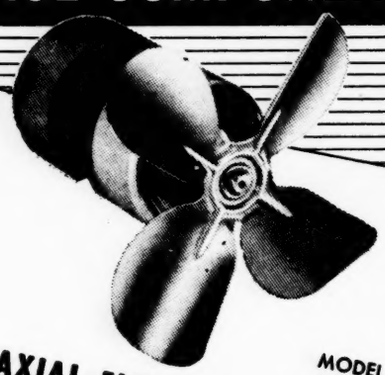
WELDED All-Steel Worm—All Sizes—All Pitches

★For replacement or production needs, Crown is now able to offer for prompt delivery its all-steel Coal Feed Screw. Available with right or left hand screw, in all sizes and pitches, tapered or straight, and in combinations of pitches. For both domestic and industrial stokers, the Crown Coal Feed Screw insures longer and continuous operation because it is all-steel and because it is machined so smoothly that wear is reduced to a minimum. This smooth surface is your assurance, too, that coal will flow freely and easily through the flights. Prompt delivery is possible because production requires less time on Crown's automatic machines and because the steel used in Crown's Coal Feed Screw while critical, is more easily procured.

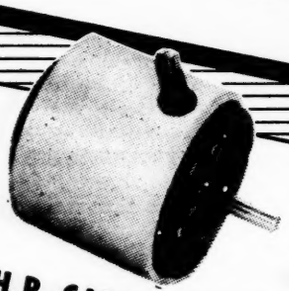
In ordering give complete specifications on size and design.

CROWN IRON WORKS COMPANY
1229 Tyler St., N. E. *Since 1878* Minneapolis, Minn.

EAD
MANUFACTURERS OF SPECIALIZED
CONTROL COMPONENTS



MODEL J 80 A
AXIAL FLOW BLOWER
AIR DELIVERY (FREE AIR)
170 C.F.M. (NEMA CODE)
65 C.F.M. (NAFM CODE)
60 cycles • 115 volts • single phase capacitor run • 3100 R.P.M. • 12 watts input • 1 oz. in. starting torque • 1 mfd. condenser required • Weight 16½ oz. Overall length 3 11/16" • Motor diameter. 1¾" • Fan: 4 blade propeller type, 4" diameter.



MODEL J 71
1/50 H.P. CAPACITOR MOTOR
60 cycles • 115 volts • Single Phase— 3400 R.P.M. • Low temperature rise High efficiency: Diameter 3 5/16" • Overall length 3⅛" • Shaft diameter 5/16" • Weight 3 lbs. Applications are for driving blowers in high ambient temperatures and for powering small control devices of all types.

MODEL J 49
60 CYCLE CAPACITOR MOTOR
115 volts • 1/250 H.P. • 3300 R.P.M. Diameter 1¾" • Length 2 11/16" • Weight 16 oz.

EASTERN AIR DEVICES, INC.
585 DEAN STREET · BROOKLYN 17, N. Y.
An Affiliate of THE FRED GOAT CO., Inc. · Est. 1893

Getting Personal

R. G. Vanderweil

R. G. Vanderweil (Locating the Panel in Radiant Heating Systems, page 63) is with the Chase Brass & Copper Co., Waterbury, Conn. In reference to his background, he wrote:

"I grew up in Vienna, Austria, took a 5-year course in mechanical engineering and had a good time skiing and climbing in those hills called the Alps. For relaxation I liked to float on our rivers with fishing tackle, tent, and several 'water' bottles. Being confronted with the more serious side of life, I decided to join my father's company — heating, piping and power plant engineers and contractors—where I made a good living as a bachelor and preferred to supervise work in the more scenic neighborhoods.

"In 1938 I arrived in the United States and to my surprise found myself working as a mechanic. A few weeks later, but not before causing extensive damage, I was back in the field of thermodynamics—heating, power plant, internal combustion engines and heat transfer—and when making out my 1939 income tax, found myself marking the column 'head of family.' I have enjoyed this position ever since and the herewith connected exemption, particularly in the last few years.

"Hobbies—radiant heating since 1935, the audible wave length of radiation called music, roaming around the country on skiis, wheels, skates or shoes."

Mr. Vanderweil worked for Baker Smith, Combustion Engineering, and Phelps Dodge, all in New York City, and The Austin Co., Seattle, Wash.

. . . Since the Last Issue

Taco Heaters, Inc., New York, has appointed **Joseph Balter** as manager of product development at the company's plant at Providence, R. I. Mr. Balter previously was associated with Burnham Boiler Corp., Irvington, N. Y., for 26 years.

Leo J. Promen, Mayor of Fond du Lac, Wis., since 1939, has been appointed to represent **Modine Manufacturing Company** in Northern Wisconsin and upper Michigan. Declining to run for re-election, Mayor Promen's tenure of office as Fond du Lac's city executive expires April 18. His association with Modine begins May 1.

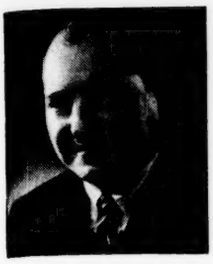
Leo J. Promen

Not a new-comer to the heating and air conditioning field, Mr. Promen was in the temperature control business from 1928 to 1932, operating out of Green Bay, Wis. He will make his headquarters at 190 E. Johnson Street, Fond du Lac.

Despatch Oven Company, Minneapolis, has opened a new sales and field engineering office at suite 1334, 221 N. La Salle St., Chicago 1, Ill. **John H. Watson** is general manager.

Tenney Engineering, Inc., Montclair, N. J., has been reorganized with **Monroe Seligman**, president. Other officials are **Cleveland A. Sewell** and **Saul S. Schiffman.** Mr. Seligman was sales manager for the American Coils Co., Newark, N. J., and Mr. Sewell was plant superintendent in charge of engineering for that company. Mr. Schiffman was an executive in the oil business and has an accounting and financial background. All of the old key personnel were retained.

R. S. Paltz has been appointed advertising manager of **Detroit Lubricator Co.**, Detroit, effective April 1, to succeed **W. H. Hohmeyer**, who becomes manager of the Company's oil burner controls division. Mr. Paltz, who has been connected with the Advertising Department for several years, has had close association with the promotional activities of all the Company's products in the refrigeration, heating and industrial control fields. Mr. Hohmeyer has been associated with the company for 18 years, the past three of which he has been advertising manager. He succeeds **F. G. Coggin** who, in turn, has been made manager of the refrigeration division to succeed J. W. Krall, resigned. Mr. Coggin has been with the company for 18 years in sales and administrative capacities.



F. G. Coggin

General Controls Co., Glendale, Calif., has appointed **A. E. Hess** as manager of its Houston branch office, covering southern Texas, Louisiana and southern Mississippi. Hess, who has had many years of experience in the engineering field for such firms as Carrier Corporation and Johnson Service Company, also spent several months on special engineering duty for the United States Navy. He joined General Controls in 1944.

Westinghouse Electric Elevator Company has announced the creation of two separate divisions to carry on the work of the Company, the air conditioning and the elevator divisions. **Ross Rathbun**, formerly manager of air conditioning, has been appointed manager of the expanded air conditioning division, which now includes the Precipitron; and **Walker G. White**, formerly sales manager, has been named manager of the elevator division. **George F. Begoon**, who for several years has directed commercial development of the Precipitron, has been named manager of the Precipitron department of the air conditioning division.

Ross Rathbun

Appointment of **Charles C. Cheyney** to the position of sales manager of **Buffalo Forge Co.**, Buffalo, N. Y., is announced. Mr. Cheyney was for a number of years Chicago representative of Buffalo Forge, and in recent years has been assistant sales manager.

Roland D. Doane has been named general sales manager of **Ingersoll Steel & Disc Div., Borg-Warner.** Mr. Doane, whose headquarters will be in Chicago, joined Ingersoll in early 1939 to handle the company's sun screen sales and merchandising. He was put in charge of the Borg-Warner Washington office in September, 1942, and continued there until the end of 1944. Much of his time concerned the Ingersoll amphibious tank program for the Bureau of Ships, U. S. Navy, which continues. In post-war production, a new type window sash and storm window will be added to Ingersoll's home equipment line, it is understood.

Roland D. Doane

PATENTED

TO INCREASE PRODUCTION

● YOU Can Obtain Greater Refrigeration Capacity from your Present Compressor by using NIAGARA DUO-PASS AERO CONDENSER.

This is possible because you use outdoor air as the cooling medium with the extra benefit of evaporative condensing! Condensing temperatures are lowered; condenser capacity is increased; head pressures are reduced —additional compressor capacity is the result.

Only the patented NIAGARA Duo-Pass makes this gain permanent because no other evaporative condenser lowers condensing temperatures to the point where deposits do not accumulate on condenser tubes. This does away with loss of time for cleaning and assures always full capacity. Write for Bulletins 91 and 93. Address Department H.V.-45.

NIAGARA BLOWER COMPANY

Over 30 Years of Service in Industrial Air Engineering

6 E. 45th St., New York 17, N.Y.

Field Engineering Offices in Principal Cities

INDUSTRIAL COOLING • HEATING • DRYING

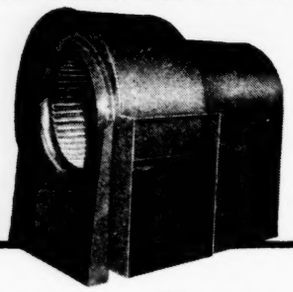
NIAGARA

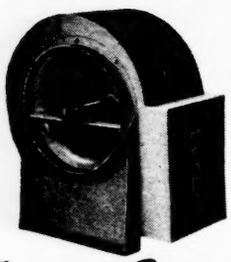
HUMIDIFYING • AIR ENGINEERING EQUIPMENT

MAKE YOUR VENTILATING JOBS *Peerless Electric*

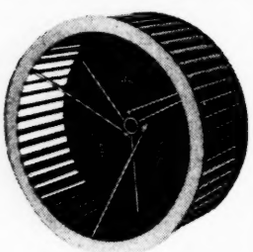
and get the benefits of 50 years' experience in building quality motors and electrical apparatus

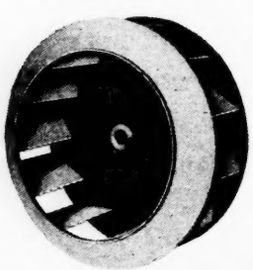
- 26 BELT DRIVE SIZES
- 12 DIRECT DRIVE SIZES





Peerless Electric
VENTILATING BLOWERS
SIZES 12" to 48"
Shown here in Arrangement 3





Peerless Electric
BLOWER WHEELS
Forward curve and backward curve blower wheels full welded construction carefully balanced for smooth, quiet rotation.

Peerless Electric
VENTILATING SETS
Belt drive units are powered with ½ to 7½ h.p. motors; direct drive units ½ to 2 h.p. motors. All units supplied with or without weatherproof hood covers for drive mechanism.

NO matter what your needs—for small jobs or large jobs—it will pay you to make Peerless your headquarters for ventilating equipment. More than 50 years of experience have given Peerless Electric the "know-how" that enters into the design and manufacture of Peerless Electric fans, blowers and ventilating equipment, entirely in our own modern plant. Peerless Electric is small enough to study your needs and special applications intimately—large enough to supply your complete requirements.

Write us for details on any standard Peerless Electric ventilating equipment, or tell us your special problems.

THE *Peerless* ELECTRIC COMPANY
WARREN, OHIO
Established 1893

Three new men have been added to the stoker division of **A. O. Smith Corp.**, Milwaukee. The three men are **T. O. Lawler**, who becomes eastern stoker sales manager, and **R. H. Stuff** and **H. H. Johns, Jr.**, who have

R. H. Stuff *T. O. Lawler* *H. H. Johns, Jr.*

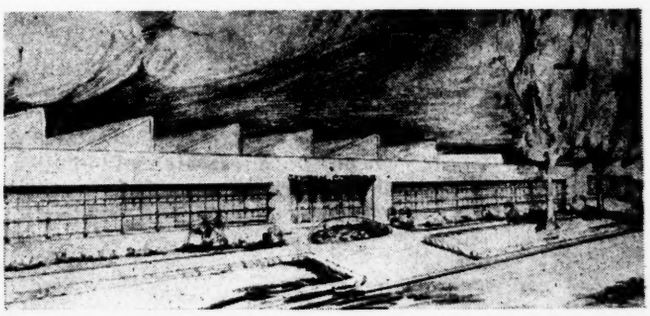
joined the north central district as regional sales managers, with offices at 310 S. Michigan Ave., Chicago. All have had wide experience and are well known in the stoker industry. Mr. Lawler's headquarters will be in the A. O. Smith New York district office at 155 E. 44th St.

The opening on March 15 of consolidated domestic and export sales offices for the member companies of **Dresser Industries, Inc.**, at 800 Chanin Building, New York City, is announced. Fifteen offices, in addition to a reception room, conference room, and stenographic room, occupy 6,000 square feet of floor space and will also provide New York headquarters for visiting officers of Dresser member companies. An auditorium seating 250 persons is additionally available in the building for sales conferences and other meetings.

Bernard Gould, formerly in charge of dip tank sales, has been appointed general sales and advertising manager of the **Aeroil Burner Co., Inc.**, West New York, N. J. Ed Skillman has taken over the Weed Burner Division of this company as assistant sales manager.

Official changes in names of two divisions of the **Westinghouse Electric & Mfg. Co.**, better to describe their expanding functions now and post-war, have been announced. Involved in the changes are the former Radio Division, which now becomes the **Industrial Electronics Division**, and the former Radio Receiver Division, which becomes the **Home Radio Division.**

General Controls Co., Glendale, Calif., manufacturer of electro-magnetic control valves, announces the completion of another step in an expansion program that will soon put three acres of factory space under roof. The immediate expansion includes a processing plant,



with 10,000 sq ft of space, in which the heat treating, anodizing, mechanical deburring, sand blasting and painting departments are housed. In addition, a new, modern office building (illustrated) will soon be ready for occupancy. This building, which embodies several innovations in design and construction, measures 235x45 ft, and will house the executive offices, the administrative, sales, advertising and sales promotion departments.

Fred D. Danford was elected treasurer of **The American Rolling Mill Company** to succeed the late M. A. Brawley who died unexpectedly on March 7 in Columbus, Ohio, while on a business trip.

Mr. Danford, who is 37 years old, was graduated from the University of Pennsylvania Wharton School of Finance in 1929. He had worked in the Armco plant during vacations, and was regularly employed soon after graduation as a clerk in the statistical department. He was appointed assistant to the controller in 1933, and in 1936 was elected assistant treasurer.

W. B. Holton, Jr., president of **Walworth Company**, manufacturers of valves and fittings, has been elected president of **The Valve Manufacturers Association.** Since March 9, 1943, Mr. Holton has been production consultant and head of the valve and fittings industry for WPB. His resignation from this position became effective February 1. Mr. Holton is also chairman of the board of trustees of the newly established Navy Industrial Association, an organization of several hundred industrial, railroad, and public utility corporations who have established the Association for the purpose of continuing, both now and post-war, effective cooperation between private business and the Navy. In accepting the presidency of the Valve Manufacturers Association, Mr. Holton succeeds Ernest Cochran, vice-president of the Chapman Valve Mfg. Co.

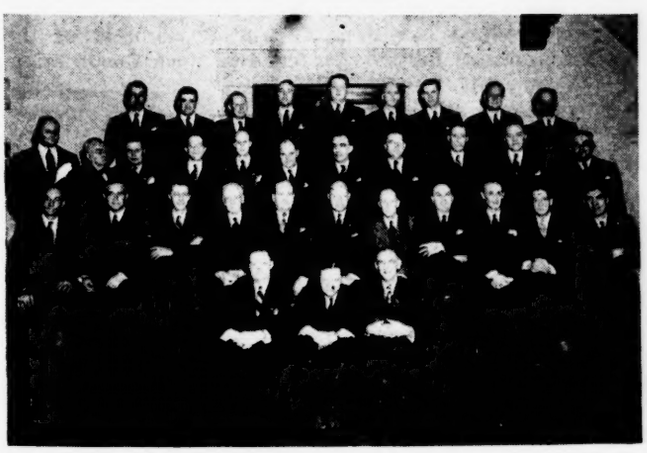
W. B. Holton, Jr.

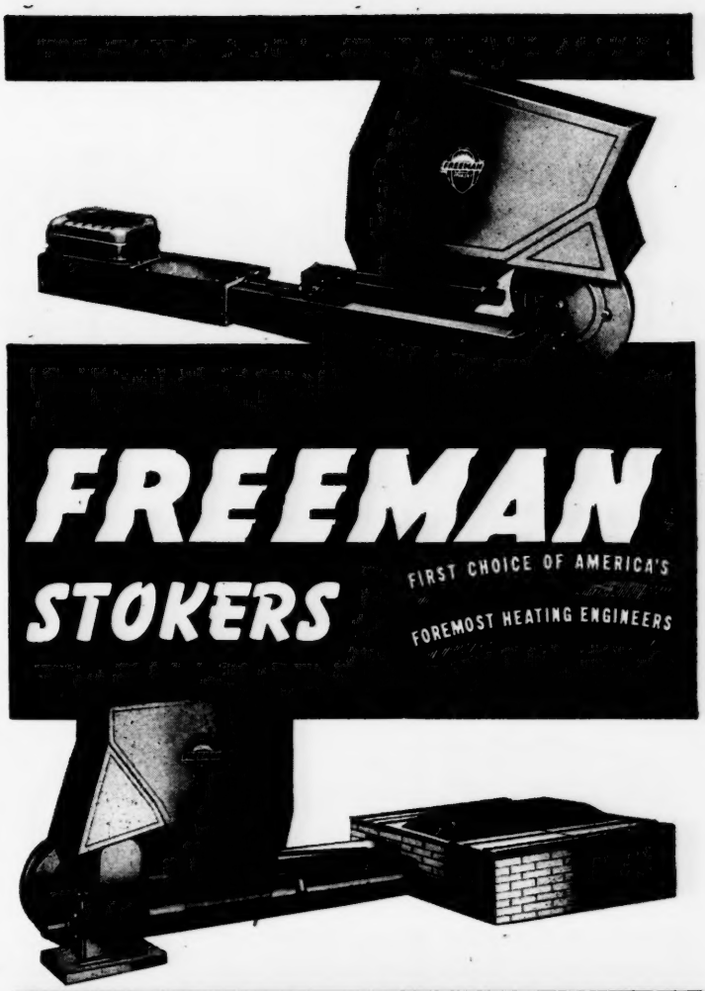
The following officers of the Association also were elected: vice-presidents, Lucien W. Moore, manager, valve and fitting department, Crane Co.; J. P. Ferguson, sales manager, Reading-Pratt & Cady Div., American Chain and Cable Co.; C. W. Burrage, secretary, Lunkenheimer Co.; secretary-treasurer: George A. Cooper, New York. Directors: C. C. Chamberlain, sales manager, Jenkins Bros.; Oliver F. Gang, vice-president, William Powell Company; C. W. Watson, vice-president, Detroit Brass & Malleable Co.; Hugh Foster, assistant sales manager, Darling Valve & Mfg. Co.; W. F. Crawford, president, The Edward Valve & Mfg. Co.; Ernest Cochran, vice-president, Chapman Valve Mfg. Co.

John Howard Collier, president of the Crane Co., Chicago, Ill., was elected a director of the **Allis-Chalmers Manufacturing Co.** He fills the post left vacant by the resignation of Capt. Lester Armour of Chicago, who has been out of the country in the service of the Navy most of the time since the outbreak of the war.

Mr. Collier also is associated with the Crane Ltd., Canada; Crane Ltd., Great Britain; Port Hope Sanitary Manufacturing Co., Ltd., Canadian Potteries Ltd., and Crane Enamelware Co. He is chairman of the board of the Trenton Potteries Co.

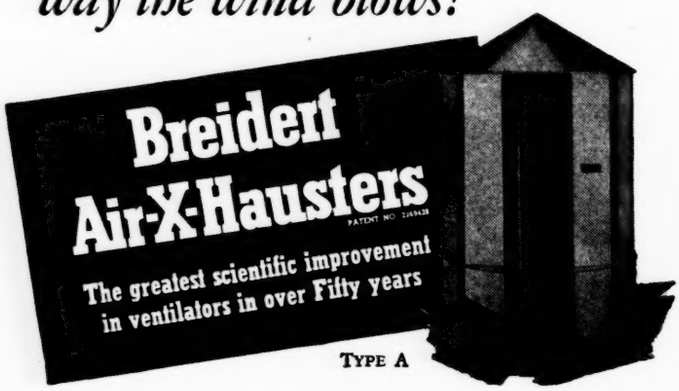
Buffalo Bolt Company, North Tonawanda, New York, recently held a sales conference. Those attending are shown in accompanying photograph.



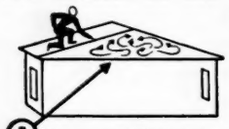


FREEMAN STOKER DIVISION
ILLINOIS IRON & BOLT CO.
918 S. MICHIGAN AVE. CHICAGO 5, ILLINOIS

Better ventilation without power costs...no matter which way the wind blows!

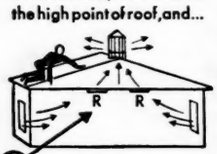


Because of the revolutionary, aerodynamically-correct design of the Breidert Air-X-Hauster, wind currents striking it from *any* angle are converted into a powerful suction force that rapidly exhausts stale air from the interior of the house, kitchen or building. The Breidert remains stationary, has no moving parts. *Back-drafts are eliminated where there is no interior negative pressure!*



1 In summer, attic temperature often reaches 30° to 40° higher than outdoors.

2 Breidert Air-X-Hauster exhausts hot, stale air at the high point of roof, and...



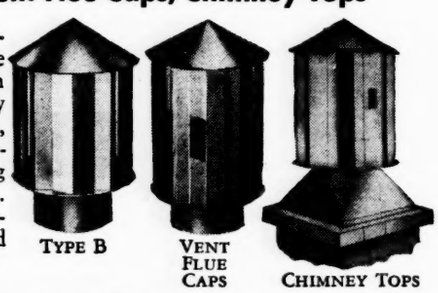
3 Fresh air enters at windows and doors, passes through register openings (R) and into attic, cooling entire house.

Unsurpassed for Kitchen Ventilation . . . The Breidert system provides a continuous, silent, effective circulation of air that exhausts heat and odors *at their source,* with no operating or maintenance expense. There are no "hang-over" cooking odors because the exhaust action of the Breidert is continuous. The neat, compact appearance of the "Type A" Breidert (above) especially recommends it for residences.

Higher Capacities Certified by Smith, Emery . . . Commercial laboratory* tests, made with wind blowing at *all* angles, prove the remarkably high capacities of the Breidert. Certified ratings are based on these unusual tests. **Smith, Emery & Co., Pacific Coast Branch Pittsburgh Testing Laboratories.*

Breidert Air-X-Hausters for Roofs, Vent Flue Caps, Chimney Tops

Breidert Air-X-Hausters provide safe, sure ventilation no matter which way the wind blows, eliminating backdraft and resulting annoyances. Thousands of installations have proved their superiority.



Write for Free Engineering Data Book

. . . contains specifications and installation data, certified capacity ratings, etc. Address Dept. R

G. C. BREIDERT CO.

634 South Spring St., Los Angeles 14, Calif.

REPRESENTATIVES LOCATED IN PRINCIPAL CITIES OF THE U. S.

Appointment of **W. R. Persons** as assistant sales manager has been announced by **The Lincoln Electric Company,** Cleveland. In his promotion to this new post, Mr. Persons will act as assistant to C. M. Taylor, vice-president and general sales manager. Among his activities concerned with the advancement and supervision of the entire Lincoln sales program, Mr. Persons will assume the responsibility of developing certain specific fields for Lincoln products. In this connection he has been working on special assignments since his transfer to the Lincoln home office at Cleveland several months ago. He is also chairman of the firm's junior board of directors.

John F. Lebor was elected secretary of the **York Corporation,** York, Pa., manufacturer of refrigeration and air conditioning equipment. Mr. Lebor, now treasurer of the company, will combine the duties of both offices and will succeed the late Vincent Keesey who served as secretary and general counsel until his death.

John F. Lebor

Mr. Lebor joined the York Corporation in 1940 as assistant to the executive vice-president. Before that he was engaged in financial work in New York City for a period of 10 years. He was appointed assistant treasurer of York in 1941 and treasurer in 1944.

Born in Portland, Ore., in 1906, Mr. Lebor graduated from the University of Oregan in 1928 and received a master's degree from the Harvard Graduate School of Business in 1930.

The Foxboro Co., Foxboro, Mass., has appointed **William A. Rock** as its resident engineer in the Corpus Christi area, under the direction of the Houston office. He has already taken up his new duties. His mail address is P. O. Box 1956, Corpus Christi, Texas. **James M. Tuttle** has joined the staff of engineers attached to the Pittsburgh office of Foxboro at 5151 Baum Blvd., Pittsburgh 24, Pa.

Young Radiator Company, Racine, Wis., announces that **H. J. Kinkade** is now a member of the Young Contract Product Division staff. In this new connection Mr. Kinkade will handle special work on evaporative cooling and similar type equipment for large engine installations. He is especially equipped for this work both by education and experience. Since acquiring his B.S. in M.E. from the University of Missouri, in 1925, Mr. Kinkade has been prominently associated with the heat transfer industry in both air conditioning and on large internal combustion engine cooling installations. He was formerly manager of evaporative cooler sales for Fairbanks Morse Co., Chicago.

H. J. Kinkade

Fred C. Wood has been appointed manager of the Washington national service office of **York Corporation.** Mr. Wood will fill the vacancy left by Rodney F. Lauer, who has been named district manager of the company's California operations with headquarters in Los Angeles. Mr. Wood first joined York in 1928 after graduating from Cornell University as a mechanical engineer. He remained at York until 1931, leaving in that year to join the Westerlin & Campbell Company, representatives in Chicago. He returned to York in 1942 to manage the air conditioning department and was later

Fred. C. Wood

transferred to an assignment in the Washington office, a position he has held until the present appointment.

Eagle-Picher Sales Co., Cincinnati, has acquired production and distribution facilities of Southern Lead Company, Dallas, Texas. Products of the Dallas plant will be sold under the Eagle-Picher name, but the personnel of Southern Lead Company will be retained under the agreement. **J. V. Murph** will serve as general manager of the Dallas plant, **D. Bentley Murph** will be in charge of production at that plant, and **D. H. Murph**, founder, will remain in a consulting capacity. Operations will be conducted under the newly created firm name, Eagle-Picher Company of Texas, with the three Messrs. Murph serving as vice-presidents.

Three new district office headquarters recently established by **American Machine and Metals, Inc.**, include the Dallas, Minneapolis and Philadelphia territories. **Oliver H. Castle** has been appointed manager of the Dallas district with headquarters in the Mercantile Bank Building in that city; **G. W. Johnson** has been appointed to head the Minneapolis district sales territory with offices in the Foshay Tower Building, and **Harold N. Ewertz** has been appointed manager of the Philadelphia district, with headquarters in the Philadelphia Savings Fund Society Building.

The General Machine Company, Inc., Emmaus, Pa., manufacturers of Electric Furnace-Man stokers, has elected **Frederick Kalmbach, Jr.**, president, succeeding his father, who remains as chairman of the board of directors. **M. Lindroth**, production manager and purchasing agent, was elected vice-president.

Taco Heaters, Inc., New York, has appointed **Russell M. Cook** as New York sales manager. Mr. Cook has just returned from overseas where he served as Captain in the Army Air Corps. Prior to his entry into the armed services he was assistant sales manager of Thatcher Furnace Company.

Peerless Foundry Company, Indianapolis, was swept by a two alarm fire February 21 with a loss estimated at $250,000.

At the annual meeting of **The Lunkenheimer Company**, Cincinnati, held March 13, the following officers and directors were elected: Frank P. Rhame, president and general manager; Homer E. Lunken, first vice-president and assistant general manager; Harry A. Burdorf, vice-president, sales; Charles W. Burrage, secretary; Chester C. Isekeit, treasurer and controller. Directors are Harry A. Burdorf, Henry G. Frost, Chester C. Isekeit, Carl M. Jacobs, Edmund P. Lunken, Homer E. Lunken, Frank P. Rhame.

E. Krefting, stoker and heating engineer, has been appointed to head the Engineering Department of **Northern Steel Stoker Corp.**, Peoria, Ill. He has had over 12 years practical stoker and heating engineering experience.

Leroy F. Keely has been appointed general sales manager of **Howell Electric Motors Co.**, Howell, Mich. Mr. Keely has spent more than 20 years in the development, sales, and application of electric motors. He is a graduate of the electrical engineering school of Michigan State College. Subsequently at the Mellon Institute he did special research and development work on insulation problems as applied to electric motors.

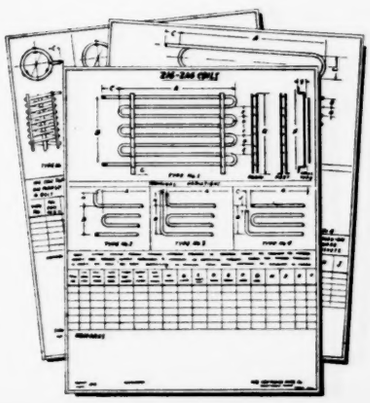
Lieutenant W. B. Henderson, USNR, formerly executive vice-president of Air Conditioning and Refrigerating Machinery Association, Inc., has returned to the United States after a tour of duty with the U. S. Naval Air Forces in the South Pacific. He has been posted to temporary duty in the Bureau of Naval Personnel at Washington.

Sam Kennard, Inc., 4821 Easton Ave., St. Louis 13, Mo., has changed its name to **Kennard Corporation.**

SPRING
is coming

BRING YOUR REFRIGERATION PROBLEMS TO WHITLOCK

Now . . . before warm weather . . . check your refrigeration plant and order necessary repairs and improvements from WHITLOCK to avoid costly shutdowns in the coming months. WHITLOCK has the manufacturing facilities and a stock of essential material. Let us work with you to keep your refrigerating equipment at peak efficiency. Write for recommendations.



Whitlock coil sketch pads—zigzags, helicals and ovals—make it easy to lay out and specify coil requirements.

Available on request.

THE WHITLOCK MANUFACTURING CO.

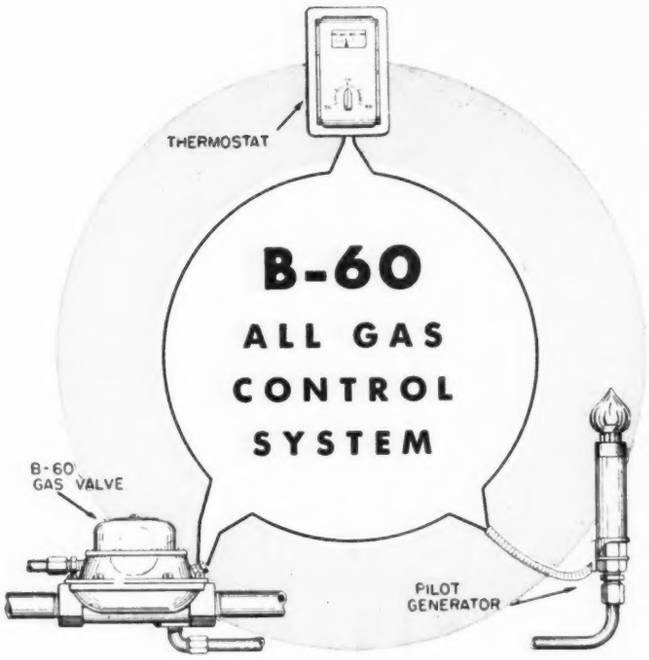
40 South Street, Elmwood, Hartford 1, Conn.

Authorized representatives in other principal cities

New York • Boston • Chicago • Philadelphia • Detroit : Richmond

In Canada: Darling Brothers, Ltd., Montreal

GENERAL CONTROLS



A completely self-contained and self-operating system, consisting of a T-80 Series Trimtherm Thermostat, a B-60 Gas Valve and a Pilot Generator. No outside current is needed.

PILOT GENERATOR—This ingenious device is an exclusive General Controls development. Designed on the thermocouple principle, the Pilot Generator supplies all necessary current for operation of the B-60 Gas Valve.

T-80 TRIMTHERM—Trimtherm's modern, streamlined appearance and advanced engineering design, make it a universal choice for accurate, remote control of room temperature.

B-60 GAS VALVE—Compact. Tamper-proof cover. Integral pilot valve assembly. Extremely strong valve body. Increased seating pressure, maximum capacities. Locked binding posts prevent turning.

For further information, contact your nearest General Controls factory branch or distributor, or write for Catalog 52-B.

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PHILADELPHIA • NEW YORK • CLEVELAND • SAN FRANCISCO • DISTRIBUTORS IN PRINCIPAL CITIES

Vent Sets

A standard size, loose leaf, 12-page bulletin 3499, giving physical data, dimensions and ratings on Limit-Load belt-driven fans up to size 5, on cast iron Baby vent sets, on direct-connected Limit-Load fans up to size 4½, and on Shortboy units in capacities up to 20,700 cfm. Fans listed in this bulletin are largely used for industrial and commercial ventilating work.—*Buffalo Forge Co., Buffalo, New York.*

Radiant Heating

How to calculate, design and install radiant heating systems for buildings ranging from monumental type structures to low-cost houses is described in a 52-page handbook, "Byers Wrought Iron for Radiant Heating." Chief purpose of book is to serve engineers and architects as a working manual. Detailed procedure is listed for figuring heat losses and piping requirements, designing the coils, supply and return mains. Data are presented on the relative merits of locating the coils in floor and ceiling. Included is a full page drawing of a floor-type radiant heating system for a representative structure in which both sinuous coils and grids are used to advantage. Said to be the most complete manual on radiant heating ever published, the book records in picture and text 23 typical installations covering a wide range of structures, including churches, medical buildings, libraries, taverns, factory buildings, office buildings and residences. In addition to chapters on the theory, history and achievements of radiant heating in more than a thousand installations functioning in the U. S., the handbook devotes 12 pages to answering the 34 questions that technical men have asked most frequently during the past seven years at lectures on radiant heating and in letters.—*A. M. Byers Company, Oliver Building, Pittsburgh, Pa.*

Air Valves

A 4-page, standard size loose leaf punched catalog VV-943 devoted to Hoffman radiator air valves for one and two pipe steam systems, one pipe vacuum, and airline systems. Describes and illustrates the four valves for radiator venting of automatically fired systems, the orifice vacuum valve for hand or stoker fired systems, three valves for mains of automatically fired systems, and three valves for venting mains of vacuum operated systems.—*Hoffman Specialty Co., 1001 York St., Indianapolis 7, Ind.*

Welding and Cutting

A standard size, 104-page catalog devoted to the company's welding and cutting apparatus. Profusely illustrated and including a number of four-color full page illustrations of various devices as well as numerous detailed illustrations of equipment and equipment use. —*Victor Equipment Co., 844-854 Folsom Street, San Francisco 7, Calif.*

Electronic Resistance Thermometer

Bulletin 230-A of 12 pages. It features the Bailey Pyrotron electronic resistance thermometers for indicating, recording and controlling models, and for temperatures between —100F and 1200F. No parts move in the measuring circuit except during temperature changes.—*Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio.*

Instrument for Measuring Thickness

Bulletin GEA-4363 of 8 illustrated pages describes a thickness gauge for measuring thickness of non-magnetic materials. It will measure thickness and type of base material, type and thickness of coating material, etc.—*General Electric Company, Schenectady, N. Y.*

Pumps

A 20-page, standard size catalog No. A145, printed in two colors and covering the company's single stage double suction centrifugal pumps. Includes typical performance data, photographs, descriptive material, cutaway photos, dimensional data, and complete selection tables. This catalog is the first in a series of "know how" manuals on pumps. When the series of approximately 10 manuals is completed, the set will be furnished in stiff cover binders.—*Economy Pumps, Inc., Hamilton, Ohio.*

Power Plants

Planning information on 10,000 to 60,000 kw. condensing turbines, surfaces condensers and auxiliaries, for building a new plant or adding generator capacity to an existing one, is presented in a 40-page Steam Power Plant Planning Guide, B-3153. Part 1 illustrates types of turbines, and charts turbine sizes and speeds. Part 2 on Performance Data covers basic operating conditions, including effect of deviation in pressures and temperatures on heat rates; regenerative feedwater heating; recommended condenser sizes, and condenser dimensions; condenser friction; impeller, propeller and axial type circulating pumps; and condensate pumps. Data is presented in chart and table form for easy selection.—*P. O. Box 868, Westinghouse Electric and Mfg. Co., Pittsburgh 30, Pa.*

Yarway Movie

A standard size, 8-page folder describing the company's new 16mm Kodachrome and sound motion picture for showing before technical societies, trade groups, engineering schools, and similar organizations. The movie covers the engineering reason behind the company's productions, typical applications and the manufacture of the product, and includes close-ups and cutaway shots of blow-offs, valves, steam traps, expansion joints, liquid level indicators, water columns and gages.—*Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa.*

Vacuum Heat

A standard size, loose leaf punched, 30-page bulletin No. 631 entitled "Dunham Differential Vacuum Heating System—Technical Data", a compact and highly informative publication describing and illustrating the Dunham differential vacuum heating system as a whole and with subsequent pages devoted to the component parts of the system. Includes capacity and dimensional information as well as a typical specification. Three pages are devoted to the company's Metro system of piping for housing projects and institutions.—*C. A. Dunham Co., 450 E. Ohio St., Chicago 11, Ill.*

Radiant Heating

Illustrated folder explaining how to handle heat generation for radiant heating systems.—*The H. B. Smith Co., Inc., Westfield, Mass.*

Shaft Couplings

An 8-page, illustrated book No. 2045 on a complete line of shaft couplings. Sizes, dimensions and list prices are given for couplings of flexible, rigid flanged face and compression types, with special emphasis on the type RC roller chain coupling. Detailed information is also given on protective casings for the RC coupling.—*Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.*

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HIGH DUST REMOVAL EFFICIENCY—because the air is reversed 21 times in its journey through the Research Air Filter—impinging on more than 30,000 tiny baffles per square foot. LOW RESISTANCE TO AIR FLOW—surface clogging reduced to a minimum.

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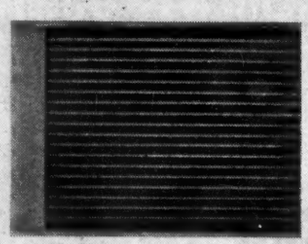

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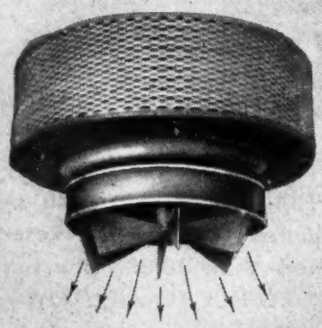

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Trane Products

The March issue of *Weather Magic*, house organ of The Trane Company, is a special edition dedicated to telling the story of the company and its products. It tells how the need for a certain type of equipment becomes known to the company, how a product is developed to fill that need, the designing that is done so that product can best be fabricated in the company's factories. It shows how the product is sold and where it may be used in the field. It contains a brief resume of Trane's educational contribution to the science of air conditioning.—*Weather Magic, The Trane Company, La Crosse, Wisconsin.*

Aircraft Heaters

A four-page folder describing aircraft heaters from 15,000 to 100,000 Btu per hr capacity, and automotive type heaters from 15,000 to 40,000 Btu per hr capacity. Illustrated in three colors the folder, form SH-2, shows cutaway views of the heaters and gives specifications of all models. It also explains a combustion process known as vapor entraining which was developed by the Company's engineers.—*Fluid Heat Div., Anchor Post Fence Co., Baltimore 24, Md.*

Plastic Fan Blades

Illustrated sheet shows the three types of fan blades available in sizes from 10 to 18 in., with pitch degrees varying from 14 to 33 degrees.—*Burden Fan and Blower Co., 8619 W. 3rd St., Los Angeles 36, Calif.*

Filters

A standard size, 8-page bulletin covering Staynew pipe line filters for air and gases and covering both pressure and vacuum types.—*Dollinger Corp., 11 Centre Park, Rochester 4, N. Y.*

House Radiant Heating

A 16-page consumer's booklet entitled "How to Choose a Heating System for Your New Home." Describes and profusely illustrates installations of house radiant heating together with information on how radiant heating systems work and cost, operating cost, and similar information.—*A. M. Byers Co., Pittsburgh, Pa.*

Hot Water Specialties

A 4-page folder, loose-leaf punched, standard size, devoted to the company's comfort package for forced circulation hot water systems and which includes a circulator, control panel, thermostat and control valve. Folder includes hook-ups for both one-pipe and two-pipe systems, together with wiring diagrams and descriptive material.—*Hoffman Specialty Co., 1001 York St., Indianapolis 7, Ind.*

Thermostats

For safe, accurate, automatic control of temperatures up to 650F, seven types of bi-metal thermostats to fill a wide range of applications are described in a new booklet announced by Westinghouse Electric and Manufacturing Company.

A 20-page booklet describing and illustrating Built-in Watchman thermostat, for aircraft equipment, instrument and bandage sterilizers, motor and wiring protection, vulcanizers, radio equipment, oil purifiers and flat-irons; Closetemp thermostat, for applications where space is limited such as in platens, irons and vulcanizers; Uni-Therm thermostat, combining close control with small size and simple, compact mounting; Sentinel thermostat, for roasters, water heaters, dehydrators and casseroles; Guardsman thermostat, particularly designed for sealing machines, ironing machines and other low-wattage heating applications, water heater thermostat, for domestic storage type heaters; and Motorguard, for

use on fractional and integral horsepower motors. Characteristics and capacities of each unit are discussed and tabled for easy selection, and cross sections, curves and drawings illustrate operation and proper mounting of units.—*P. O. Box 868, Westinghouse Electric and Mfg. Co., Pittsburgh 30, Pa.*

ARMY – NAVY

AWARDS

The Bishop & Babcock Manufacturing Co.,
Plants 1 and 2, Cleveland, Ohio.
Aeroil Burner Co., Inc., West New York, N. J.
Economy Pumps, Inc., Hamilton, Ohio.
J. A. Zurn Mfg. Co., Erie, Pa.

INDUSTRIAL DEGREE-DAYS

February, 1945

City	55F Base	45F Base
Baltimore, Md.	455	200
Buffalo, N. Y.	808	528
Chicago, Ill.	700	420
Cleveland, Ohio	709	430
Detroit, Mich.	766	486
Indianapolis, Ind.	604	333
New York, N. Y.	577	299
Philadelphia, Pa.	524	254
Pittsburgh, Pa.	587	319
St. Louis, Mo.	549	299

Canadian Degree-Days for February, 1945*

City	February 1945	February Normal	Cumulative, Sept. 1 to Feb. 28 1945	Cumulative, Sept. 1 to Feb. 28 Normal
Calgary, Alta.	1308	1355	5863	6666
Charlottetown, P. E. I.	1246	1338	5326	5666
Crescent Valley, B. C.	997	1112	4991	5743
Edmonton, Alta.	1436	1501	6832	7315
Fort William, Ont.	1512	1582	6985	7204
Grand Prairie, Alta.	1484	1456	7072	7456
Halifax, N. S.	1095	1198	4828	5139
London, Ont.	1190	1240	5679	5253
Medicine Hat, Alta.	1394	1406	6339	6498
Moncton, N. B.	1310	1392	5838	6106
Montreal, P. Q.	1305	1392	6381	6075
North Bay, Ont.	1389	1492	6944	6653
Ottawa, Ont.	1338	1459	6554	6282
Penticton, B. C.	871	969	4417	4779
Porquis Junction, Ont.	1557	1764	7861	8064
Prince George, B. C.	1176	1305	6256	6677
Quebec City, P. Q.	1305	1481	6295	6688
Regina, Sask.	1641	1764	7317	8137
St. John, N. B.	1190	1266	5436	5652
Saskatoon, Sask.	1641	1635	7374	7911
Toronto, Ont.	1093	1211	5233	5164
Vancouver, B. C.	669	736	3557	3797
Victoria, B. C.	605	689	3065	3414
Windsor, Ont.	1081	1148	4988	4877
Winnipeg, Man.	1610	1775	7279	8091

*These data are supplied through the courtesy of the Meteorological Division, Air Services Branch, Department of Transport, Canada, with the cooperation of N. W. Etter, Heating Engineerfi Enamel & Heating Products Limited, Sackville, N. B.

The Department reports some slight revisions in the figures for January, as published in last month's issue. Corrected figures are: Crescent Valley, B. C., 1116; Grand Prairie, Alta., 1717; Moncton, N. B., 1494; Montreal, P. Q., 1841; Penticton, B. C., 1023; Quebec City, P. Q., 1755; and St. John, N. B., 1432.

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DUX-SULATION deadens metallic sounds and when applied to inside of duct quiets air-borne noises and reduces vibration.

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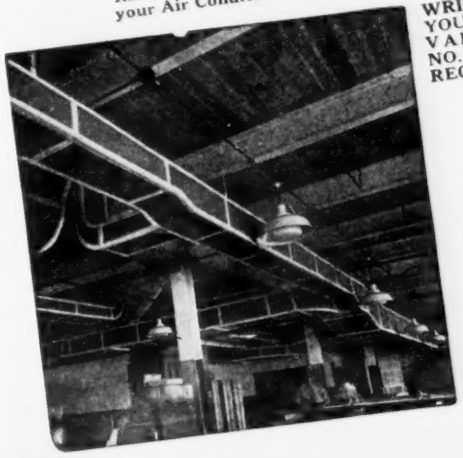

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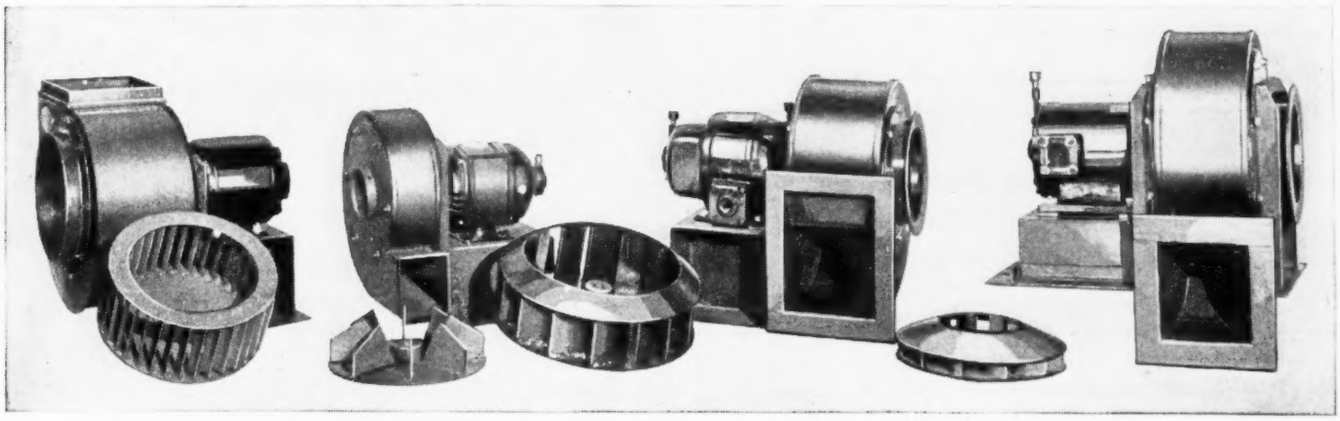

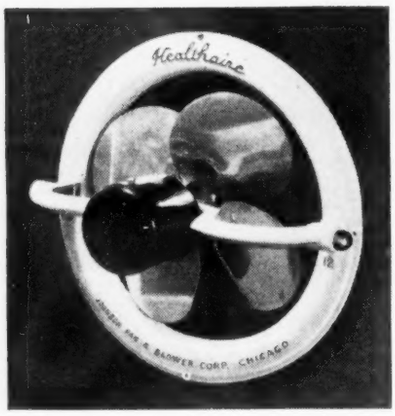

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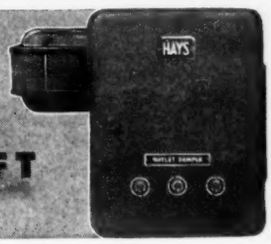

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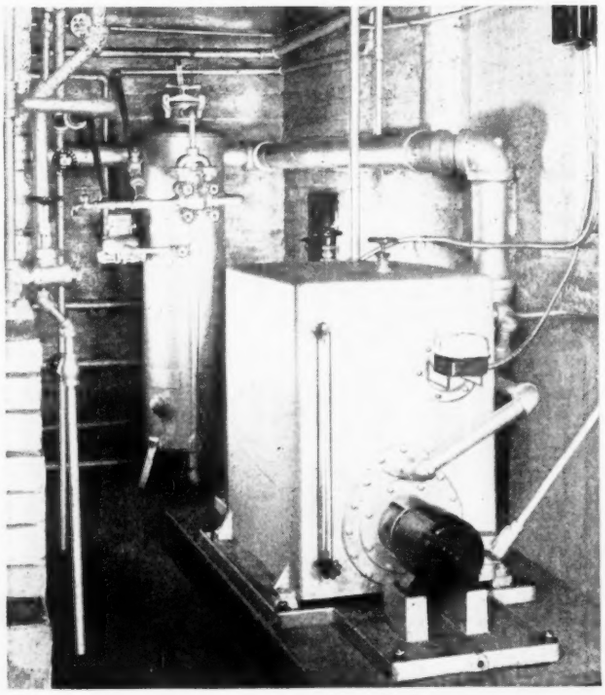

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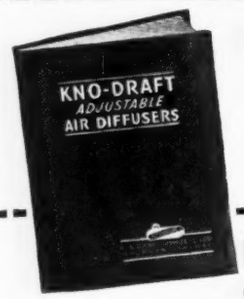

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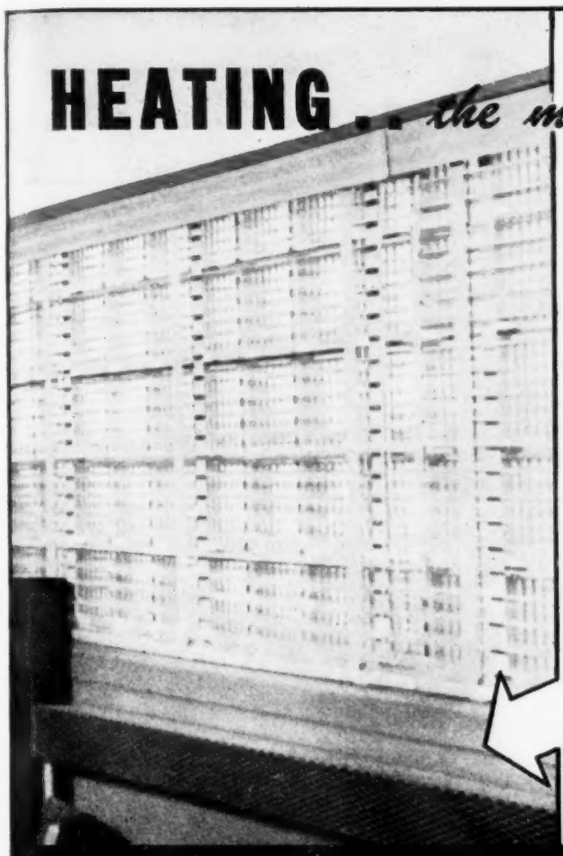

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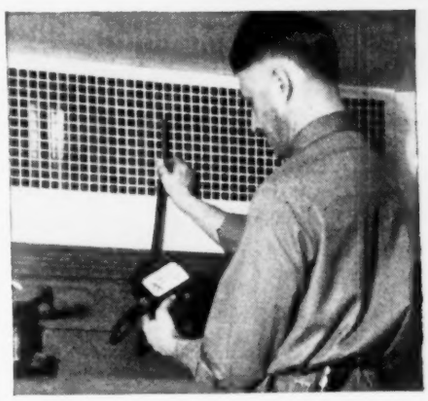

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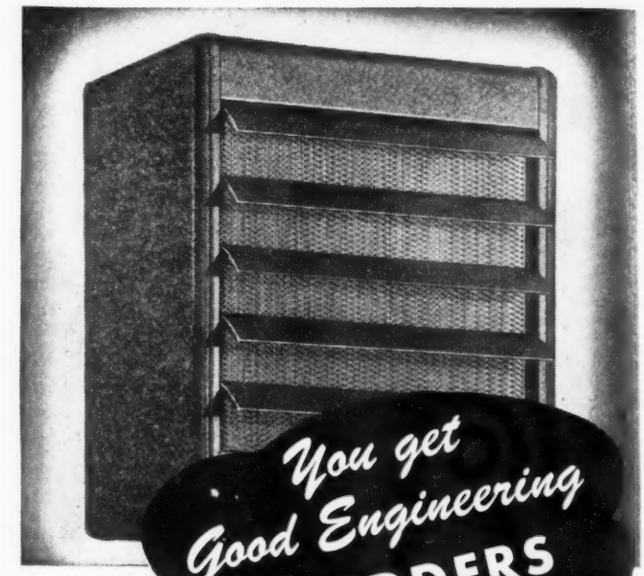

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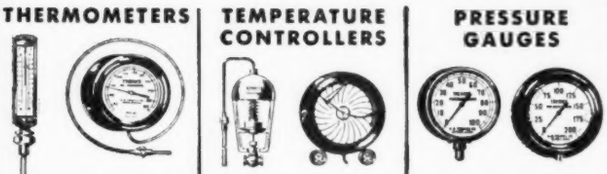

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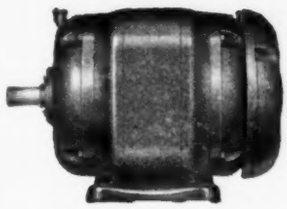

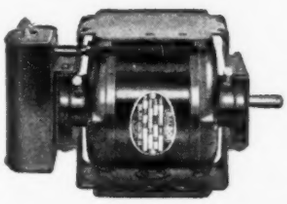

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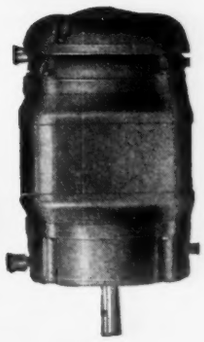

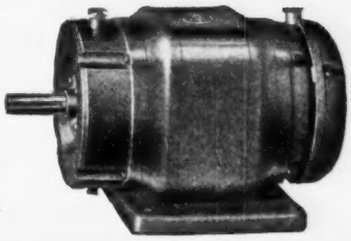

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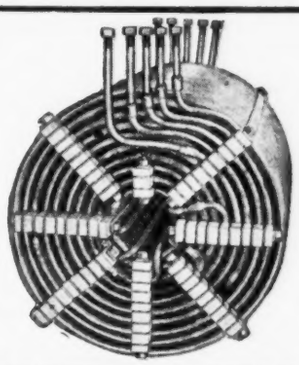

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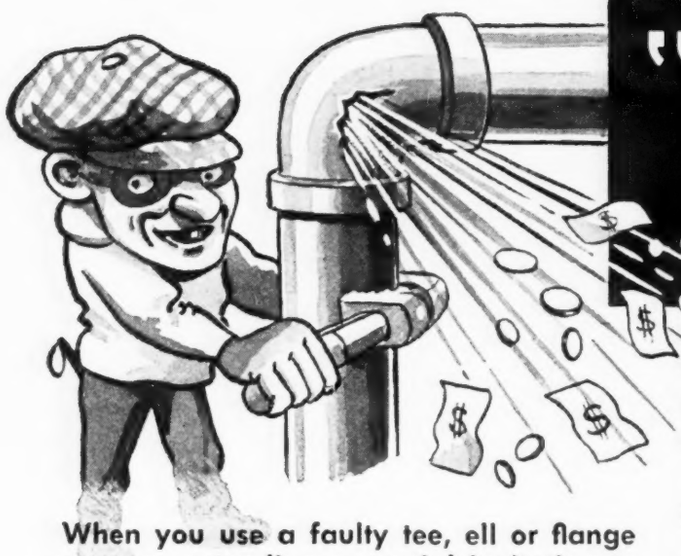

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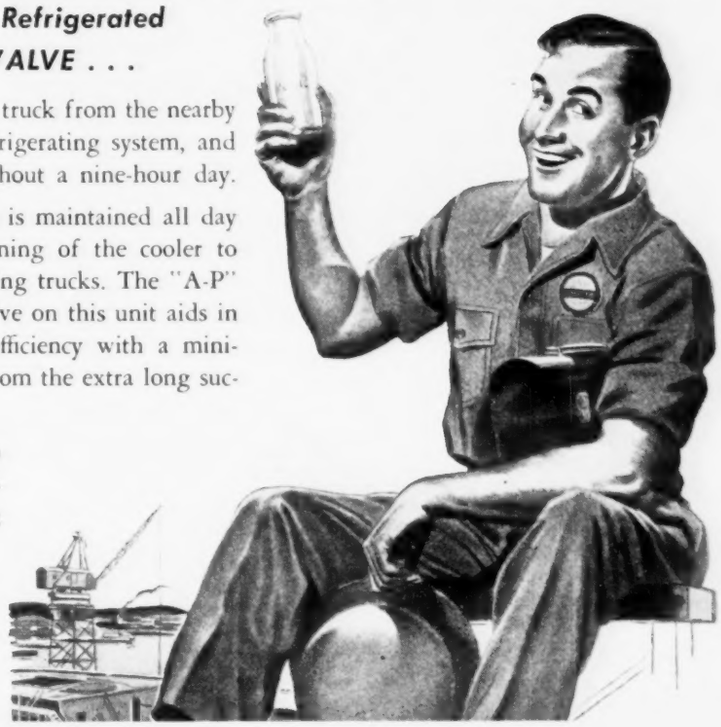

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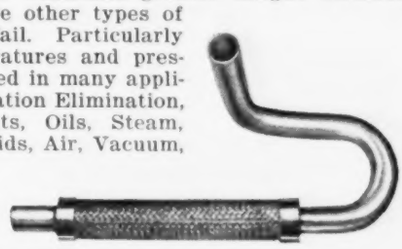

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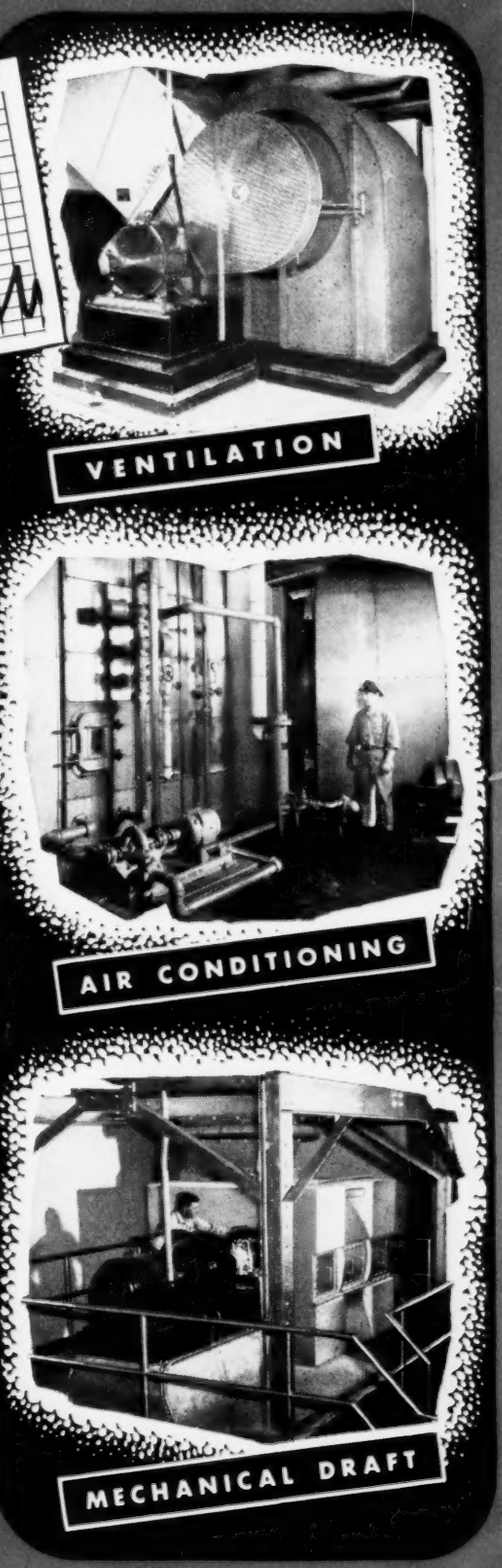

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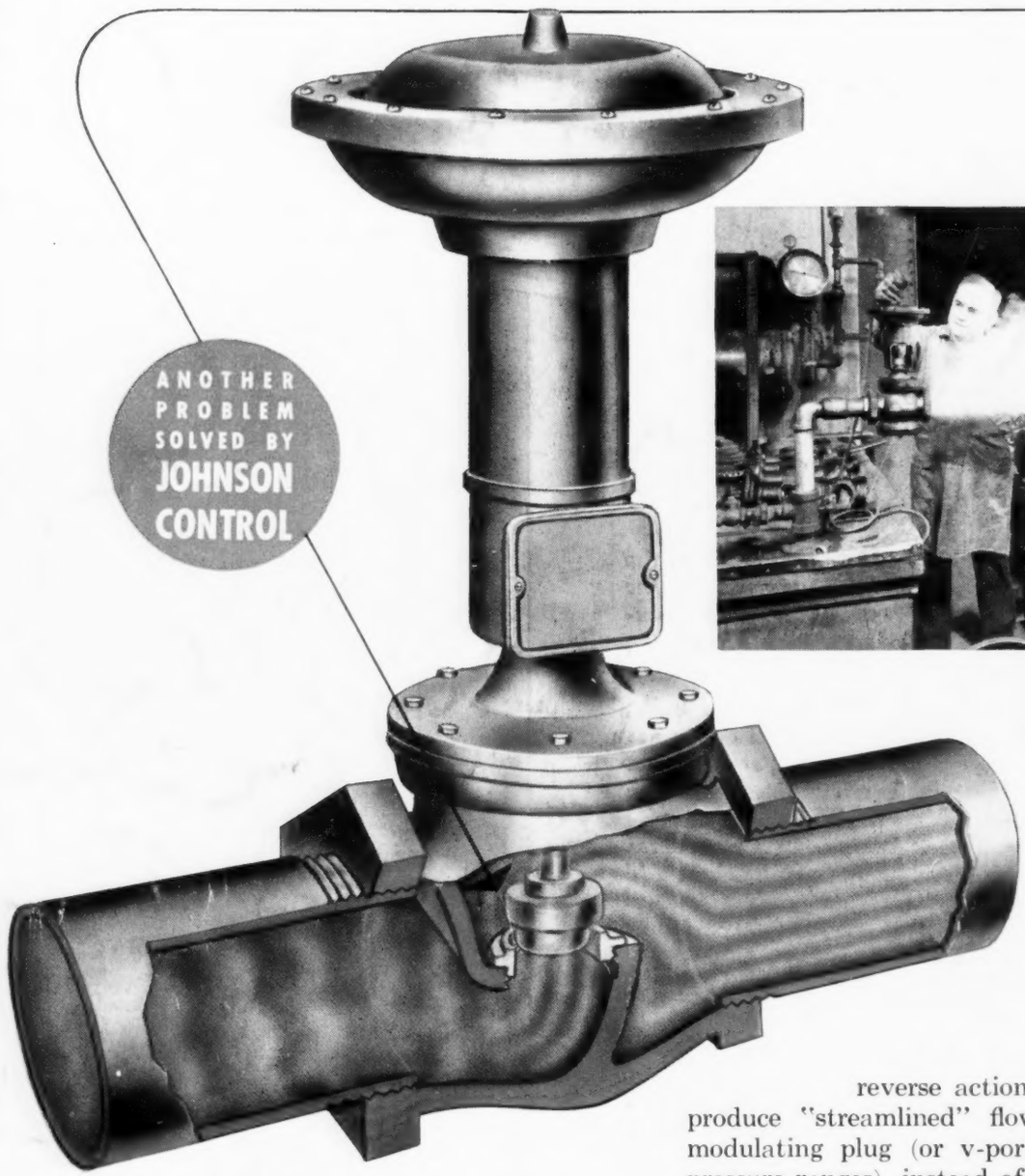

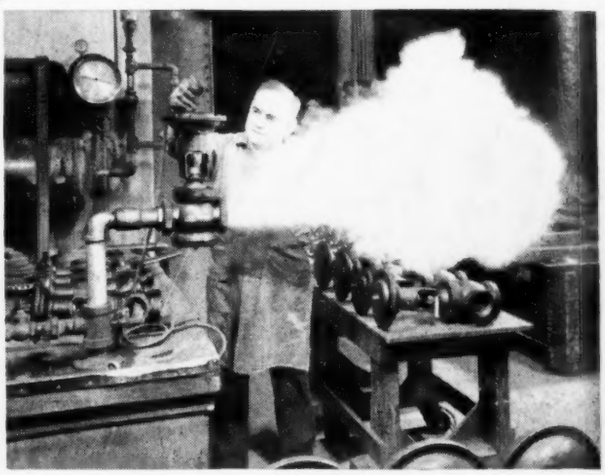

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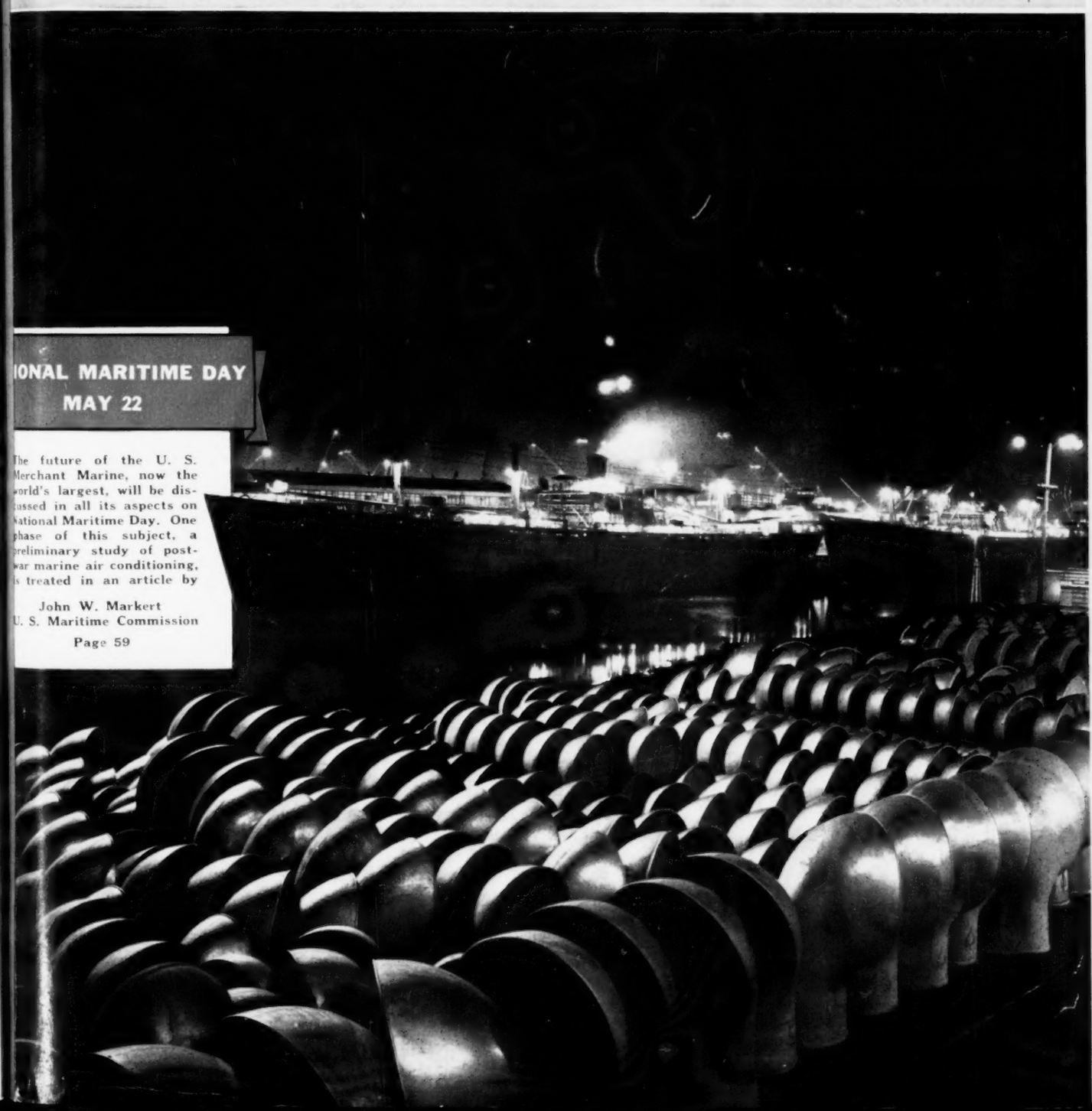
DETROIT

AIR CONDITIONING, REFRIGERATION, PIPING, AIR SANITATION, HEATING AND VENTILATION



IONAL MARITIME DAY
MAY 22

The future of the U. S. Merchant Marine, now the world's largest, will be discussed in all its aspects on National Maritime Day. One phase of this subject, a preliminary study of post-war marine air conditioning, is treated in an article by

John W. Markert
U. S. Maritime Commission

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Central Heating from an Available Steam Source Eliminates Individual Boilers and Cuts Fuel Costs

Twenty years ago a group of manufacturers in a compact industrial area made arrangements to purchase and pipe steam from an available source nearby. This made it possible to shut down their own boilers—which, because of smoke regulations, had become antiquated. Also, by dispensing with labor, coal, ash handling and other costs, they effected material savings—in fact, one of the largest users paid for his share of the steam distribution lines out of these savings in 6 months operation.

Today the originally installed steam piping, insulated and protected by Ric-wiL Conduit, is still enabling their plants to enjoy lower steam costs and freedom from individual boiler worries.

A recent survey by a postwar plan commission indicates the feasibility of increasing the boiler capacity of the same plant to serve an adjacent industrial and residential area comprising five square miles at a substantial profit!

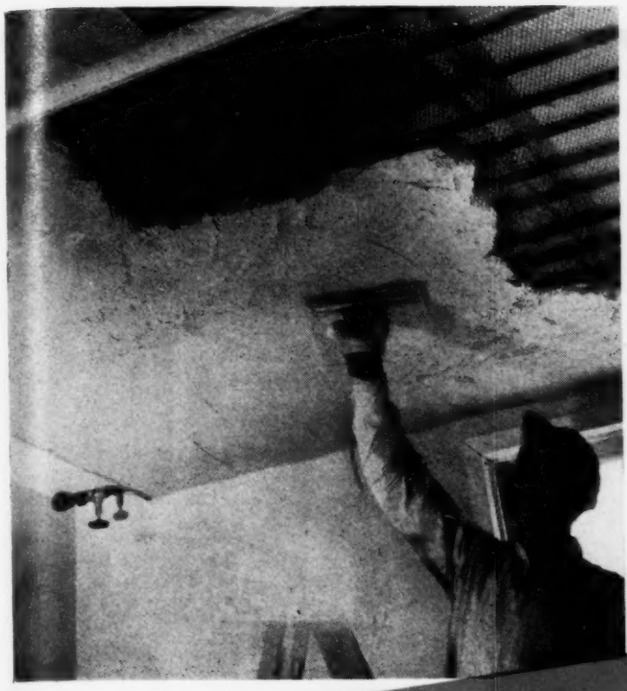
Central Heating is practical for industrial, commercial, institutional and residential groups. Special studies of typical installations are available upon request.

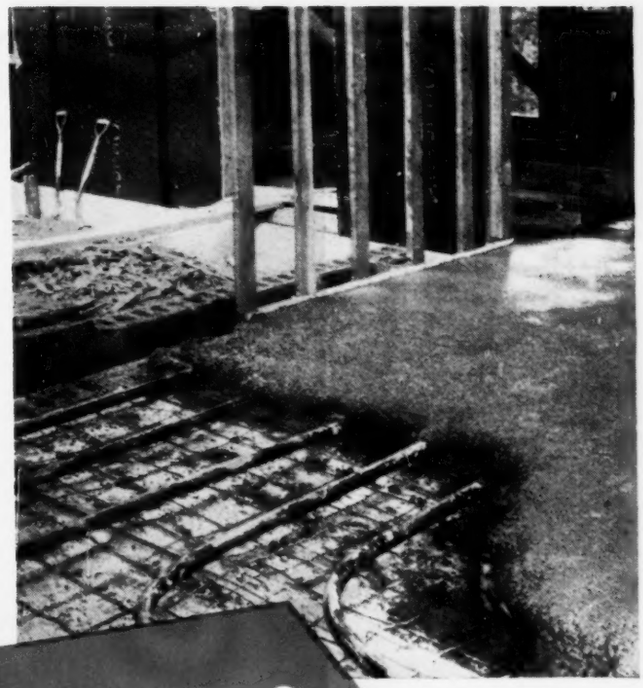
Any Industrial or Residential Area can Enjoy these Advantages

- Savings of 15% or better in fuel costs.
- Elimination of individual boiler worries.
- Cleaner, healthier working conditions.
- Reduction of smoke and soot in neighboring residential areas.
- Extra production space in plants.
- Decreased fire and explosion hazard.
- Private coal delivery and ash removal eliminated.
- Uniform clean heat—whenever required.
- Unfailing source of "process" steam and hot water.

RIC-WIL INSULATED PIPE CONDUIT SYSTEMS
THE RIC-WIL COMPANY · CLEVELAND, OHIO
AGENTS IN PRINCIPAL CITIES

TECHNOLOGY DEPT.





Here's why

BYERS RADIANT HEATING

"gets along" so well with plaster ceilings and concrete floors

There is one question about Byers Radiant Heating that must be in the minds of a number of heating men, for it crops up with surprising frequency. It has to do with the effect of the embedded heating coils on concrete floors . . . and to a lesser extent, the effect of embedded ceiling coils on plaster.

It goes without saying, of course, that the pipe and concrete must expand and contract at the same rate when heated and cooled if difficulties are to be avoided. The important thing to remember is that wrought iron meets this requirement; it and concrete have practically identical rates of thermal expansion. This is one of the big advantages of wrought iron, that recommend its use.

It is not necessary to depend on theory alone for the answer, however, for the question is answered in terms of practical experience. A major portion of the thousand Byers Radiant Heating jobs now operating are hot water systems installed in plaster ceilings or concrete floor slabs. The evidence is overwhelming that in any properly designed, properly installed system, no difficulty whatever with thermal cracking need be anticipated.

Naturally, it is important to handle the pouring and curing of the concrete in floors in the correct manner. The Portland Cement Association will undoubtedly be glad to give you the recommendations on best practice, if you contact them.

This subject emphasizes the importance of selecting proper materials in installing radiant heating, for the qualities and the properties of the pipe have a big bearing on ease and speed of installation, dependability, durability, and all-around satisfaction. Byers Wrought Iron meets all these requirements to an unusual degree. In addition to its ability to "work" with concrete, it has a high rate of heat emission; it can be readily formed and welded, which speeds installation; and its corrosion resistance has been conclusively proven.

We have been intimately connected with radiant heating for several years, and have probably accumulated more first-hand knowledge and experience than can be found in any other one place. This pool of knowledge has been tapped in preparing a new technical bulletin, which condenses the entire story of Byers Radiant Heating into 52 fact-filled pages. We will be glad to send you a copy on request.

A. M. Byers Co., Pittsburgh, Pa. Established 1864. Boston, New York, Philadelphia, Washington, Chicago, St. Louis, Houston, Seattle, San Francisco.

CORROSION COSTS YOU MORE THAN WROUGHT IRON

BYERS
GENUINE WROUGHT IRON
TUBULAR AND HOT ROLLED PRODUCTS
ELECTRIC FURNACE ALLOY STEELS · OPEN HEARTH ALLOY STEELS
CARBON STEEL TUBULAR PRODUCTS